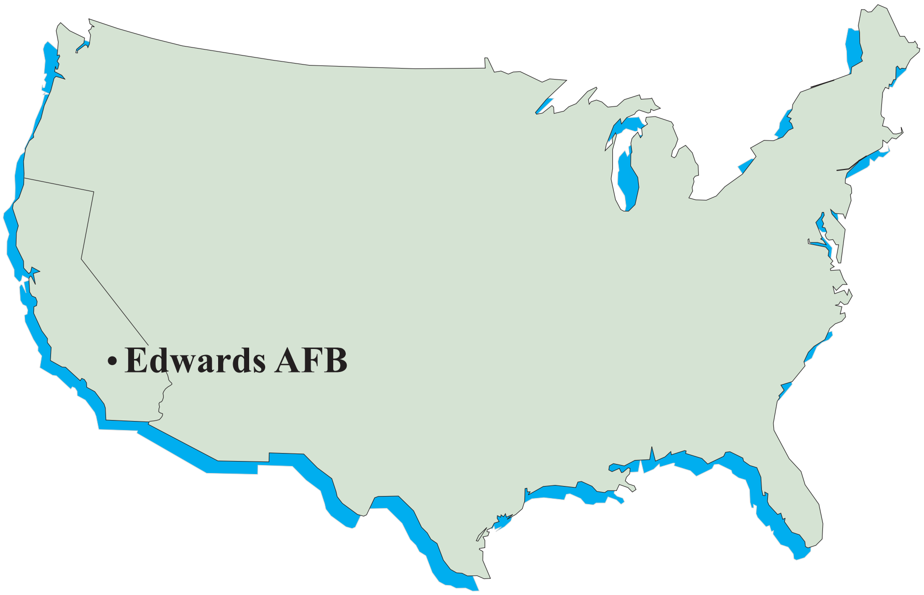
Air Force Flight Test Center
Edwards Air Force Base, California

ENVIRONMENTAL ASSESSMENT FOR THE ORBITAL REENTRY CORRIDOR FOR GENERIC UNMANNED LIFTING ENTRY VEHICLE LANDING AT EDWARDS AIR FORCE BASE



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DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE FLIGHT TEST CENTER (AFMC)
EDWARDS AIR FORCE BASE, CALIFORNIA

MEMORANDUM FOR GOVERNMENT AGENCIES, PUBLIC OFFICIALS, LIBRARIES, PUBLIC GROUPS, AND INTERESTED INDIVIDUALS

FROM: AFFTC/EM
5 East Popson Avenue, Bldg. 2650A
Edwards AFB CA 93524-1130

SUBJECT: *Final Environmental Assessment (EA) and Finding of No Significant Impact (FONSI) for Orbital Reentry Corridor for Generic Unmanned Lifting Entry Vehicle Landing at Edwards Air Force Base* (December 2002), State Clearinghouse #2002074009

1. Attached for public and agency notification is the *Final EA and FONSI for the Orbital Reentry Corridor for Generic Unmanned Lifting Entry Vehicle Landing at Edwards Air Force Base* (July 2002). The document has been prepared in compliance with the President's Council on Environmental Quality Regulations and the National Environmental Policy Act.

2. The proposed action is designation of an orbital reentry corridor for the recovery of flights of generic unmanned space transportation vehicles from low earth orbit to final approach and landing at Edwards Air Force Base, California in support of Air Force and NASA research and development programs between 2004 and 2009. Specific areas analyzed for environmental impact were air quality, cultural resources, drainage, economic, geologic, noise, public services, hazardous materials/waste, vegetation, water, wildlife, and land use. The State Clearinghouse public review of the Draft EA was completed on August 30, 2001. All comments have been addressed in the Final EA and a FONSI has been prepared for the project.

3. For further information regarding this project please contact Mr. Gary Hatch at AFFTC/EM, 5 E. Popson Avenue, Edwards AFB, CA 93524-1130, telephone (661) 277-1454, or email gary.hatch@edwards.af.mil. Thank you for your interest in this project.

ROBERT W. WOOD
Director, Environmental Management

FINDING OF NO SIGNIFICANT IMPACT FOR THE ORBITAL REENTRY CORRIDOR FOR GENERIC UNMANNED LIFTING ENTRY VEHICLE LANDING AT EDWARDS AIR FORCE BASE (AFB)

1.0 INTRODUCTION

The U.S. Air Force proposes to establish an orbital reentry corridor into Edwards AFB, California, for generic, medium size, unmanned lifting entry vehicles (LEVs). The Proposed Action is being developed as a cooperative effort among the Department of Defense Air Force Flight Test Center (AFFTC), the National Aeronautics and Space Administration (NASA) Dryden Flight Research Center (DFRC), and the Federal Aviation Administration (FAA) to support the development and test of future unmanned entry vehicles for both NASA and the Air Force. The overall purpose of the Proposed Action is to designate a generic orbital reentry corridor for the recovery of flights of unmanned LEVs from low earth orbit to final approach and landing at Edwards AFB in support of future Air Force and NASA research and development programs. The unmanned LEV reentry corridor is defined by the trajectory (ground track and altitude) of the vehicle as it reenters the earth's atmosphere from space.

2.0 DESCRIPTION OF THE PROPOSED ACTION AND ALTERNATIVES CONSIDERED

A Western Orbital Reentry Corridor was selected as Alternative A. This corridor would be approximately 140 nautical miles wide crossing the California coast and the unmanned LEV would cross the coastline at an elevation of approximately 108,000 feet above mean sea level (msl). A Northwestern Orbital Reentry Corridor was selected as Alternative B. This corridor would be approximately 240 nautical miles wide as it crossed the California/Oregon coast and the unmanned LEV would cross the coastline at an elevation of approximately 160,000 feet above msl. The No-Action Alternative was also analyzed, in which the orbital reentry corridor would not be established.

3.0 ENVIRONMENTAL CONSEQUENCES

The Region of Influence (ROI) of the proposed project consists of Edwards AFB and all areas within the azimuth range for Alternatives A and B. Resources within the ROI have been identified and evaluated under the following categories: air quality, airspace, cultural resources, environmental justice, geology and soils, hazardous waste/hazardous materials, infrastructure, land use, natural resources, noise, public/emergency services, safety, socioeconomics, and water resources. No potentially significant impacts were identified to any of these areas under the alternatives considered.

Decisions regarding the significance of impacts, as define under NEPA, are based on a consensus of the interpretation of environmental laws, rules, and regulations by cognizant federal, state, and local agencies; previously certified environmental documentation for similar projects; and trained and experienced professionals in each environmental field.

Cumulative Impacts

Alternatives A and B would have no potentially significant cumulative impacts to airspace, land use, noise, or to any other issue area analyzed in this EA. Therefore, no mitigation measures are recommended.

Unavoidable Adverse Impacts

A crash of the LEV would result in unavoidable adverse impacts. However, due to the extremely low probability of a crash, establishment of the Alternative A (Western Approach) corridor or Alternative B (Northwestern Approach) corridor would not result in any unavoidable adverse impacts.

Short-term Versus Long-term Productivity of the Environment

Since no new development would be required under the Orbital Reentry Corridor Program and current Air Force or contractor personnel from other bases would be used for the program, neither Alternative A nor B would involve any short- or long-term changes in population or productivity of the environment.

Irreversible and Irretrievable Commitments of Resources

This EA only addresses reentry and landing of an unmanned LEV. Reentry and landing of an unmanned LEV within the Alternative A (Western Approach) corridor or the Alternative B (Northwestern Approach) corridor would not require an irreversible or irretrievable commitment of resources. Irreversible or irretrievable commitment of resources that would be involved in other phases of the program (e.g., vehicle fabrication, launch, refurbishment, flights with specific payloads) would be addressed in separate environmental documentation. Implementation of Alternative C (No-Action Alternative) would also not require an irreversible or irretrievable commitment of resources.

4.0 CONCLUSION

Based on a careful review of the analyses and data in the Environmental Assessment, no significant impact to the natural or human environment would be expected from implementation of the Proposed Action. No mitigation measures are recommended. Therefore, issuance of a Finding of No Significant Impact is warranted, and preparation of an Environmental Impact Statement, pursuant to the National Environmental Policy Act of 1969 (Public Law 91-190) is not required.

Robert W Wood
ROBERT W. WOOD
Director, Environmental Management

2 January 2003
Date

FINDING OF NO SIGNIFICANT IMPACT FOR THE ORBITAL REENTRY CORRIDOR FOR GENERIC UNMANNED LIFTING ENTRY VEHICLE LANDING AT EDWARDS AIR FORCE BASE (AFB)

1.0 INTRODUCTION

The U.S. Air Force proposes to establish an orbital reentry corridor into Edwards AFB, California, for generic, medium size, unmanned lifting entry vehicles (LEVs). The Proposed Action is being developed as a cooperative effort among the Department of Defense Air Force Flight Test Center (AFFTC), the National Aeronautics and Space Administration (NASA) Dryden Flight Research Center (DFRC), and the Federal Aviation Administration (FAA) to support the development and test of future unmanned entry vehicles for both NASA and the Air Force. The overall purpose of the Proposed Action is to designate a generic orbital reentry corridor for the recovery of flights of unmanned LEVs from low earth orbit to final approach and landing at Edwards AFB in support of future Air Force and NASA research and development programs. The unmanned LEV reentry corridor is defined by the trajectory (ground track and altitude) of the vehicle as it reenters the earth's atmosphere from space.

2.0 DESCRIPTION OF THE PROPOSED ACTION AND ALTERNATIVES CONSIDERED

A Western Orbital Reentry Corridor was selected as Alternative A. This corridor would be approximately 140 nautical miles wide crossing the California coast and the unmanned LEV would cross the coastline at an elevation of approximately 108,000 feet above mean sea level (msl). A Northwestern Orbital Reentry Corridor was selected as Alternative B. This corridor would be approximately 240 nautical miles wide as it crossed the California/Oregon coast and the unmanned LEV would cross the coastline at an elevation of approximately 160,000 feet above msl. The No-Action Alternative was also analyzed, in which the orbital reentry corridor would not be established.

3.0 ENVIRONMENTAL CONSEQUENCES

The Region of Influence (ROI) of the proposed project consists of Edwards AFB and all areas within the azimuth range for Alternatives A and B. Resources within the ROI have been identified and evaluated under the following categories: air quality, airspace, cultural resources, environmental justice, geology and soils, hazardous waste/hazardous materials, infrastructure, land use, natural resources, noise, public/emergency services, safety, socioeconomics, and water resources. No potentially significant impacts were identified to any of these areas under the alternatives considered.

Decisions regarding the significance of impacts, as define under NEPA, are based on a consensus of the interpretation of environmental laws, rules, and regulations by cognizant federal, state, and local agencies; previously certified environmental documentation for similar projects; and trained and experienced professionals in each environmental field.

Cumulative Impacts

Alternatives A and B would have no potentially significant cumulative impacts to airspace, land use, noise, or to any other issue area analyzed in this EA. Therefore, no mitigation measures are recommended.

Unavoidable Adverse Impacts

A crash of the LEV would result in unavoidable adverse impacts. However, due to the extremely low probability of a crash, establishment of the Alternative A (Western Approach) corridor or Alternative B (Northwestern Approach) corridor would not result in any unavoidable adverse impacts.

Short-term Versus Long-term Productivity of the Environment

Since no new development would be required under the Orbital Reentry Corridor Program and current Air Force or contractor personnel from other bases would be used for the program, neither Alternative A nor B would involve any short- or long-term changes in population or productivity of the environment.

Irreversible and Irretrievable Commitments of Resources

This EA only addresses reentry and landing of an unmanned LEV. Reentry and landing of an unmanned LEV within the Alternative A (Western Approach) corridor or the Alternative B (Northwestern Approach) corridor would not require an irreversible or irretrievable commitment of resources. Irreversible or irretrievable commitment of resources that would be involved in other phases of the program (e.g., vehicle fabrication, launch, refurbishment, flights with specific payloads) would be addressed in separate environmental documentation. Implementation of Alternative C (No-Action Alternative) would also not require an irreversible or irretrievable commitment of resources.

4.0 CONCLUSION

Based on a careful review of the analyses and data in the Environmental Assessment, no significant impact to the natural or human environment would be expected from implementation of the Proposed Action. No mitigation measures are recommended. Therefore, issuance of a Finding of No Significant Impact is warranted, and preparation of an Environmental Impact Statement, pursuant to the National Environmental Policy Act of 1969 (Public Law 91-190) is not required.

ROBERT W. WOOD
Director, Environmental Management

2 January 2003
Date

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SUMMARY
ENVIRONMENTAL ASSESSMENT FOR THE ORBITAL REENTRY CORRIDOR FOR GENERIC LIFTING ENTRY VEHICLE LANDING AT EDWARDS AIR FORCE BASE

1.0 INTRODUCTION

This Environmental Assessment (EA) evaluates the potential environmental impacts associated with the proposed establishment of an orbital reentry corridor into Edwards Air Force Base (AFB), California, for generic, medium size, unmanned lifting entry vehicles (LEVs). An unmanned LEV capable of landing on a normal aircraft runway is seen as a key to increasing access to space at a reasonable cost. There are several research programs devoted to developing unmanned LEVs that would provide reliable and reusable means of transporting small payloads from earth orbit. This EA only addresses the reentry and landing phases of the intended test vehicle program. Analysis of other phases (e.g., vehicle fabrication, launch, refurbishment) will be the responsibility of the intended test vehicle program office; separate environmental documentation would be required under these phases of the program. The U.S. Air Force Flight Test Center (AFFTC) is representing the Department of Defense (DoD) as the lead agency. The National Aeronautics and Space Administration (NASA) Dryden Flight Research Center (DFRC) and Federal Aviation Administration (FAA) are cooperating agencies in the preparation of this EA.

This EA was prepared in accordance with the requirements of the National Environmental Policy Act (NEPA) of 1969, as amended (42 United States Code 4321 *et seq*.); the Council on Environmental Quality Regulations for Implementing the Procedural Provisions of NEPA (40 Code of Federal Regulations [CFR] 1500–1508); Air Force Instruction 32-7061, *The Environmental Impact Analysis Process* dated July 6, 1999, as codified in 32 CFR Part 989; and NASA policy and procedures (14 CFR Part 1216, Subpart 1216.3). This EA provides sufficient documentation to support a determination whether a Finding of No Significant Impact should be issued or an Environmental Impact Statement is required.

2.0 PURPOSE AND NEED

The overall purpose of the Proposed Action is to designate a generic orbital reentry corridor for the recovery of flights of unmanned LEVs from low earth orbit to final approach and landing at Edwards AFB in support of future Air Force and NASA research and development programs. With the recent reassignment of the United States Air Force Space and Missile Center to the Air Force Space Command, there is more focus on the military's need for reusable space vehicles. The United States must achieve significant reductions in the cost of access to space. One way to accomplish this is to accelerate progress toward second generation reusable unmanned LEV systems with attractive cost structures. An unmanned LEV capable of landing on a normal runway or hard surface (lakebed) is seen as a key to increasing access to space at a reasonable cost. To support that need, the Air Force is developing several approaches to support the technology that will be applied to both operational space vehicles and hypersonic weapon systems. Current concepts for technology development involve testing unmanned vehicles and require the capability to support both flight tests and operational flights of such vehicles in the continental United States.

The Proposed Action is being developed as a cooperative effort between AFFTC (DoD), NASA DFRC, and FAA to support the development and test of future unmanned entry vehicles for both NASA and the Air Force. Specifically, the Proposed Action focuses on the recovery of unmanned LEVs returning from low earth orbit to final approach and landing at Edwards AFB. This document serves as a programmatic assessment of acceptable reentry corridors and as the foundation for environmental processes required to obtain the necessary approval for a first flight of an unmanned space transportation vehicle[1] in 2004. Edwards AFB is a cost-effective location for reentry landings because of the facilities in place, its remote location, and previous success in its use for Space Shuttle and other unmanned vehicle flights and landings.

To fulfill the purpose of the National Space Policy and National Space Transportation Policy, the AFFTC, in cooperation with NASA DFRC, needs to identify a suitable reentry corridor for unmanned LEVs. The unmanned LEVs must be flight tested in a realistic operational environment (flight corridor) to demonstrate critical technologies needed for recovery from low earth orbit. Without compromising public safety, unduly interfering with commercial and private aircraft, or adversely affecting the environment in the proposed reentry corridor, the unmanned LEV needs to be tested through all flight regimes that could occur during its reentry to a safe landing on Earth. Establishing a reentry corridor from space and completing the programmatic environmental document based on an unmanned LEV configuration would reduce the time required for environmental process approval for a specific unmanned LEV configuration. The selection of Edwards AFB as the preferred landing site for the reentry corridor is based on extensive capabilities that exist at the site and the fact that flight corridors would most likely be over sparsely populated areas from the west coast to the inland Edwards AFB landing site.

3.0 DESCRIPTION OF THE PROPOSED ACTION

Alternatives were identified following a two-step process. First, a Quantitative Risk Analysis was performed against all reentry azimuths between 220 degrees and 020 degrees relative to Edwards AFB extending from the approach end of Runway 22 on-base and encompassing all land, population centers, and aircraft flight routes along each azimuth. This study analyzed the expectation of causality (E_C) at each point along the ground track and probability of aircraft impact (P_I) against the FAA and Air Force standards. The ranges of azimuths with an E_C less than or equal to 30 causalities per million missions and P_I less than 1 impact in 10 million missions were identified for further consideration. Next, the Air Force selected the corridors for Alternatives A and B for assessment under this EA based on the most probable orbital reentry track leading to the preferred landing site.

A Western Orbital Reentry Corridor was selected as Alternative A. This corridor would be approximately 140 nautical miles wide crossing the California coast, and would include that airspace extending from the Heading Alignment Circle intercept point at 34 degrees 54 minutes north latitude, 117 degrees 40 minutes west longitude extending along the 250-degree radial crossing the coastline at 34 degrees 21 minutes north latitude, 119 degrees 25 minutes west longitude; and along the 290-degree radial crossing the coastline at 35 degrees 57 minutes north latitude and 121 degrees 27 minutes west longitude. The unmanned LEV would cross the coastline at an elevation of approximately 108,000 feet above mean sea level.

A Northwestern Orbital Reentry Corridor was selected as Alternative B. This corridor would be approximately 240 nautical miles wide as it crossed the California/Oregon coast. It would extend from the Heading Alignment Circle (HAC) intercept point at 34 degrees 54 minutes north latitude, 117 degrees 40 minutes west longitude along the 325-degree radial crossing the California coast at 41 degrees 38 minutes north latitude, 124 degrees 06 minutes west longitude, and along the 337-degree radial crossing the Oregon coast at 45 degrees 58 minutes north latitude, 123 degrees 56 minutes west longitude. The unmanned LEV would cross the coastline at an elevation of approximately 160,000 feet above mean sea level.

---

[1] This EA could support the Federal Aviation Administration licensing approval process for vehicles returning from the International Space Station functioning as a cargo shuttle, prototype for a crew rescue vehicle (first unmanned flight test), or recovery vehicle from another commercial venture in space.

The landing site is required to be a DoD or NASA flight test facility. Important selection criteria for the unmanned LEV landing site include radar tracking capabilities, test range support facilities, and range safety considerations. Recovery on land provides the greatest flexibility for recovery of the unmanned LEV. Landing options include use of hard surface runways, lakebed runways, and parachute type landings to either concrete Runway 22 or Rogers Dry Lakebed.

Edwards AFB has historically been selected as a primary testing site for new aircraft and space vehicles because of the remote surroundings and viable landing options. The hard surface runways and the hard flat surface of the Rosamond and Rogers Dry Lakebeds have proven ideal for parachute/parasail landings and normal aircraft landings. The open terrain and lack of vertical features has contributed to the safe recovery of many test vehicles, something that would not have been possible in a less remote area.

Based on the selection criteria developed, AFFTC and NASA DFRC facilities at Edwards AFB provide the support facilities and flight test capabilities necessary to most effectively meet the projected test requirements for landing of an unmanned LEV. The required runway length for the LEV is between 8,000 and 12,000 feet. The primary runway at Edwards AFB, Runway 22, is hard surfaced, 15,000 feet long, and 300 feet wide. No new or specialized equipment would be required to support the unmanned LEV approach and landing.

The unmanned LEV reentry corridor is defined by the trajectory (ground track and altitude) of the vehicle as it reenters the earth's atmosphere from space. Approximately 30 minutes before touchdown, the unmanned LEV would begin entering the atmosphere at an altitude of about 400,000 feet. At approximately 45,000 feet, and within 5 nautical miles of Edwards AFB, the unmanned LEV would maneuver to intercept the final landing approach at the desired altitude and velocity.

The final approach and landing of the unmanned LEV would be accomplished via a shuttle-type landing pattern on either Runway 22 or on the Rogers Dry Lakebed at Edwards AFB by way of an HAC. As the unmanned LEV approaches the Edwards AFB landing site, it would be maneuvered to line up with the centerline of the runway.

3.1 ALTERNATIVES CONSIDERED AND DISMISSED FROM FURTHER CONSIDERATION

A wide range of entry azimuths from 220 degrees to 020 degrees, crossing from just north of the Los Angeles basin to east of Ridgecrest, California, were considered and evaluated in the Quantitative Risk Analysis. The risk analysis quantified risks to persons, property, and aircraft from the return from orbit and descent of an unmanned LEV. Estimated failure rates, unmanned LEV breakup characteristics, trajectory modeling, and seasonal atmospheric variations (atmospheric density and wind modeling), population distribution and sheltering characteristics, and air traffic (aircraft density) modeling, were used to provide a risk assessment of alternative entry corridors.

The risk analysis indicated those entry corridors over the Los Angeles basin (with azimuths of between 220 and 249 degrees), and entry corridors over Bakersfield, San Francisco, Stockton, and Fresno (with azimuths between 295 and 325 degrees) were higher risk than the preferred corridors, and using the estimated vehicle reliability for an experimental unmanned LEV would exceed the expectation of casualty standards established by the Air Force or FAA. Consequently, consideration of additional entry corridors along those azimuths was eliminated, although they could be potential reentry corridors for operational unmanned LEVs with proven high reliability.

The risk analysis also identified azimuths from 350 degrees to 020 degrees as acceptable trajectories for reentry from polar orbit, however, these azimuths were not evaluated as part of this EA because a polar orbit reentry corridor would not normally be considered as a primary corridor for flight tests of an experimental unmanned LEV.

3.2 NO-ACTION ALTERNATIVE

Under Alternative C, the No-Action Alternative, an orbital reentry corridor for generic LEV landing at Edwards AFB would not be established and no impacts would be generated. Under the No-Action Alternative, designation of a generic orbital reentry corridor for the recovery of flights of unmanned LEVs from low earth orbit to final approach and landing at Edwards AFB would not occur, and therefore, future Air Force and NASA research and development programs involving unmanned LEVs would not be supported.

4.0 SUMMARY OF ENVIRONMENTAL IMPACTS

Because the relatively few number of flights related to this proposed action are less than 1 percent of the normal flight activity at Edwards AFB, the activities associated with the Orbital Reentry Corridor Program would not result individually or cumulatively in significant impacts to the quality of the human or natural environment.

1.0 PURPOSE AND NEED FOR ACTION

1.1 INTRODUCTION

This Environmental Assessment (EA) evaluates the potential environmental impacts associated with the proposed establishment of an orbital reentry corridor into Edwards Air Force Base (AFB), California, for generic, medium size, unmanned lifting entry vehicles (LEVs).

This EA was prepared in accordance with the requirements of the National Environmental Policy Act (NEPA) of 1969, as amended (42 United States Code [U.S.C.] 4321 *et seq*.); the Council on Environmental Quality (CEQ) Regulations for Implementing the Procedural Provisions of NEPA (40 Code of Federal Regulations [CFR] 1500–1508); Air Force Instruction 32-7061, *The Environmental Impact Analysis Process*; and National Aeronautics and Space Administration (NASA) policy and procedures (14 CFR Part 1216, Subpart 1216.3). The U.S. Air Force Flight Test Center (AFFTC) is representing the Department of Defense (DoD) as the lead agency. NASA Dryden Flight Research Center (DFRC) and the Federal Aviation Administration (FAA) are cooperating agencies in the preparation of this EA.

1.2 LOCATION OF PROPOSED ACTION

Edwards AFB is located in the Antelope Valley region of the western Mojave Desert in Southern California. It is about 60 miles northeast of Los Angeles, California. The base occupies an area of approximately 300,800 acres or 470 square miles. Portions of the base lie within Kern, Los Angeles, and San Bernardino counties (Figure 1-1).

1.3 BACKGROUND

The U.S. Air Force provides support to NASA and commercial access-to-space flight test activities, in addition to assessing leading-edge space technology for potential DoD use. A tremendous amount of research is being focused on reducing today's high cost of space travel while increasing its reliability and safety. Second generation programs focus on the development of reusable launch vehicles (RLVs) like an unmanned LEV. An unmanned LEV capable of landing on a normal aircraft runway is seen as a key to increasing access to space at a reasonable cost. There are several research programs devoted to developing unmanned LEVs that would provide reliable and reusable means of transporting small payloads from earth orbit. Development and flight testing of such vehicles requires a reentry corridor from space into Edwards AFB to allow the safe return of the research vehicle.

Historically, Edwards AFB has been an excellent site for testing aircraft, lifting bodies, and space and supersonic vehicles such as X-vehicles (e.g., X-15, X-24A, X-38, X-40A). Edwards AFB was the primary site for Approach and Landing Tests (ALTs) for the Space Shuttle orbiter and was selected primarily because of its remote location, multiple runways, and dry lakebed. Of the 107 Space Shuttle orbiter landings, 48 occurred at Edwards AFB (28 landings on Runway 22 and 20 landings on the lakebed), one at White Sands, and the remainder at Kennedy Space Center. The unmanned LEV would land on Runway 22 at Edwards AFB. Edwards AFB continues to be the preferred alternate landing site for Space Shuttle orbiters for emergencies and when weather at Kennedy Space Center is outside acceptable parameters.

The generic, medium size, unmanned LEV designated for this analysis is represented by the general aerodynamic configuration of the lifting body SV-5 shape (Figure 1-2). This configuration is similar to the X-23 Prime vehicle and the X-24A lifting body. The generic vehicle is assumed to weigh 25,000

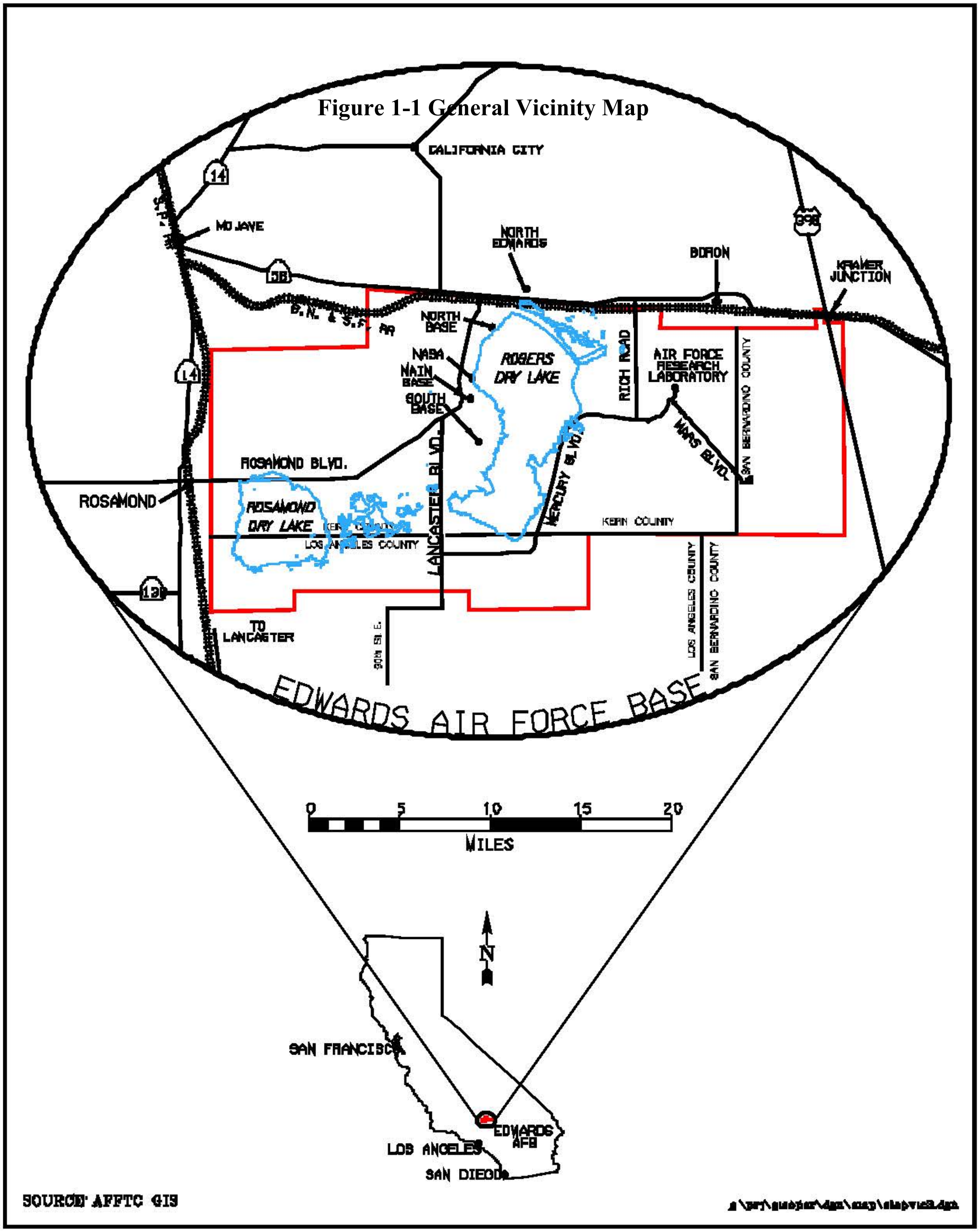
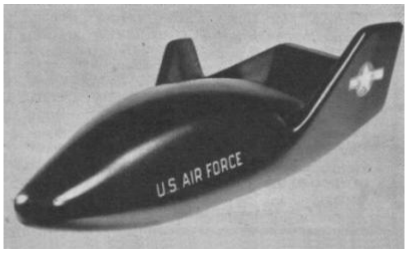


Figure 1-1 General Vicinity Map
CALIFORNIA CITY
14
S.P. RR
MOJAVE
58
NORTH EDWARDS
BORON
395
KRAMER JUNCTION
B.N. & S.F. RR
NORTH BASE
NASA
MAIN BASE
SOUTH BASE
ROGERS DRY LAKE
RICH ROAD
AIR FORCE RESEARCH LABORATORY
SAN BERNARDINO COUNTY
MARS BLVD.
MERCURY BLVD.
14
ROSAMOND BLVD.
ROSAMOND
ROSAMOND DRY LAKE
KERN COUNTY
LOS ANGELES COUNTY
LANCASTER BLVD.
KERN COUNTY
LOS ANGELES COUNTY
SAN BERNARDINO COUNTY
138
TO LANCASTER
90th St. E.
EDWARDS AIR FORCE BASE
0
5
10
15
20
MILES
N
SAN FRANCISCO
EDWARDS AFB
LOS ANGELES
SAN DIEGO

SOURCE: AFFTC GIS

Figure 1-1 General Vicinity Map

pounds during entry, and to be 30 feet long by 15.5 feet wide (in comparison the Space Shuttle is 230,000 pounds during entry and is 122 feet long and 78 feet wide at its widest point [Figure 1-3]). The vehicle will have expended all residual propellant before it reaches the reentry gate at 400,000 feet above mean sea level (msl).



Note: The unmanned LEV is approximately 1/4 the size of the Space Shuttle.

Figure 1-2 Example of an Unmanned LEV Shape

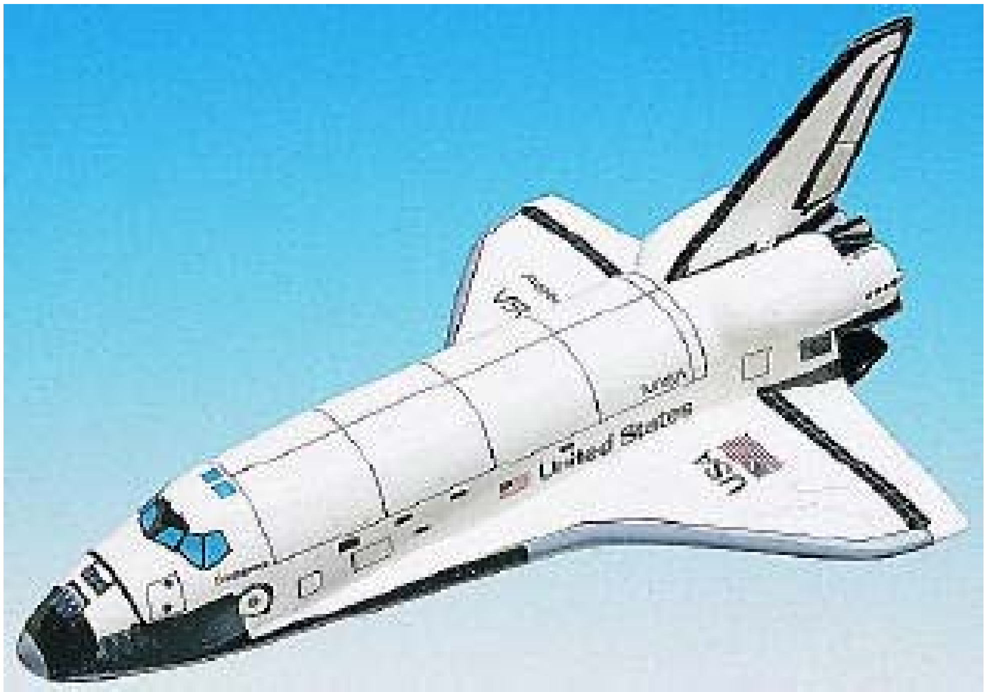


Figure 1-3 Space Shuttle *Discovery*

1.4 PURPOSE OF THE PROPOSED ACTION

The Proposed Action is to designate a generic orbital reentry corridor for the recovery of flights of unmanned LEVs from low earth orbit to final approach and landing at Edwards AFB in support of future Air Force and NASA research and development programs. These programs could include vehicles that have similar design and flight characteristics and that have risk (as documented in the Quantitative Risk Analysis [QRA], Appendix A) and environmental effects less than or equal to the unmanned LEV used in this analysis.

The United States has recognized that space transportation costs must be significantly reduced in order to make continued exploration, development, and use of space affordable. In August 1994, the National Space Transportation Policy divided the responsibility for developing expendable launch vehicles and reusable launch vehicles between the DoD and NASA, respectively. In the fall of 1996, the National Space Policy reinforced the efforts to enable the development of a next-generation RLV. It reaffirmed the commitment to developing new launch vehicles that would ensure America's continued role as the world's space leader. The Space Transportation section of the National Space Policy addresses the commercial launch sector, stating that "assuring reliable and affordable access to space through U.S. space transportation capabilities is fundamental to achieving National Space Policy goals." The National Space Policy provides these guidelines [in part]:

- Balance efforts to modernize existing space transportation capabilities and invest in development of improved future capabilities.
- Maintain a strong transportation capability and technology base.
- Reduce the cost of current space transportation systems while improving reliability, operability, responsiveness, and safety.
- Foster technology development and demonstration to support future decisions on the development of the next-generation RLV.
- Encourage, to the fullest extent feasible, the cost-effective use of commercially provided Unites States products and services.

With the recent reassignment of the United States Air Force Space and Missile Center to the Air Force Space Command, there is more focus on the military's need for reusable space vehicles. To support that need, the Air Force is defining several approaches to developing technology that will be applied to both operational space vehicles and hypersonic weapon systems. Current concepts for technology development involve testing unmanned vehicles and require the capability to support both flight tests and operational flights of such vehicles in the continental United States.

The Proposed Action is being developed as a cooperative effort among AFFTC (DoD), NASA DFRC, and FAA to support the development and test of future unmanned entry vehicles for both NASA and the Air Force. Specifically, the Proposed Action focuses on the recovery of unmanned LEVs returning from low earth orbit to final approach and landing at Edwards AFB. This document serves as a programmatic assessment of acceptable reentry corridors and as the foundation for environmental processes required to obtain the necessary approval for a first flight of an unmanned space transportation vehicle[1] in 2004. Table 1-1 lists the projected/estimated maximum number of flights that would be conducted under this program.

---

[1] This EA could support the FAA licensing approval process for vehicles returning from the International Space Station functioning as a cargo shuttle, prototype for a crew rescue vehicle (first unmanned flight test), or recovery vehicle from another commercial venture in space.

Table 1-1 Projected/Estimated Unmanned LEV Flights

Year	Number of Flights
2004	1
2005	2
2006	2
2007	5
2008	5
2009	12

This EA only addresses the reentry and landing phases of the intended test vehicle program. Analysis of other phases (e.g., vehicle fabrication, launch, and refurbishment) will be the responsibility of the intended test vehicle program office. Edwards AFB is a cost-effective location for reentry landings because of its facilities, its remote location, and its successful use for Space Shuttle and other unmanned vehicle flights and landings.

1.5 NEED FOR THE PROPOSED ACTION

To fulfill the purpose of the National Space Policy and National Space Transportation Policy, the AFFTC, in cooperation with NASA DFRC, needs to identify a suitable reentry corridor for unmanned LEVs. Reentry corridors are instrumental to the development of low cost, second-generation space transportation vehicles. The unmanned LEVs must be flight tested in a realistic operational environment (flight corridor) to demonstrate critical technologies needed for recovery from low earth orbit. Without compromising public safety, unduly interfering with commercial and private aircraft, or adversely affecting the environment in the proposed reentry corridor, the unmanned LEV needs to be tested through all flight regimes that could occur during its reentry and landing. Establishing a reentry corridor from space and completing the programmatic environmental document based on a unmanned LEV configuration will reduce the time required for environmental process approval for a specific unmanned LEV configuration.

Use of the corridors analyzed and documented in this EA by other entities is possible if they meet the same criteria and parameters defined and used in this EA and QRA. Use of the corridors by other civilian or commercial programs may have additional requirements beyond those imposed by the Air Force and NASA DFRC. It will be the responsibility of the civilian or commercial program office to identify and meet those additional requirements. The selection of Edwards AFB as the preferred landing site for the reentry corridor is based on extensive capabilities that exist at the site and the fact that flights in corridors would most likely be over sparsely populated areas from the west coast to the inland Edwards AFB landing site.

1.6 ENVIRONMENTAL IMPACT ANALYSIS PROCESS

The NEPA established a national policy to protect the environment and ensure that federal agencies consider the environmental effects of actions in their decision-making. The CEQ is authorized to oversee and recommend national policies to improve the quality of the environment. The CEQ published regulations that describe how NEPA should be implemented. These regulations encourage federal agencies to develop and implement procedures that address the NEPA process in order to avoid or minimize adverse effects on the environment. Title 32 CFR Part 1989 addresses implementation of NEPA as part of the Air Force planning and decision-making process.

1.7 FUTURE USE OF THIS DOCUMENT

Future proposed projects would be reviewed and evaluated to determine if they fall within the scope of this EA. If so, then these projects may use the analysis presented here and tier off this document. In some cases, a supplement to this EA may be required. If a supplemental EA is required, a new Finding of No Significant Impact (FONSI) would be necessary. Future actions that are found to result in significant impact to the environment that could not be mitigated to a level of insignificance would need to be addressed in an Environmental Impact Statement.

1.8 STRUCTURE OF THIS EA

This EA presents the analysis and description of potential environmental impacts that could result from the Proposed Action and Alternatives. As appropriate, the affected environment and environmental consequences of the Proposed Action and Alternatives are presented in terms of regional and site-specific descriptions.

Chapter 2.0 contains descriptions of Alternative A (Proposed Action), Alternative B, and Alternative C (No-Action Alternative). Project information and the general parameters associated with the Proposed Action are also described in Chapter 2.0.

Chapter 3.0 provides regional and site-specific information related to air quality, airspace, cultural resources, environmental justice, geology and soils, hazardous materials/hazardous waste, infrastructure, land use, natural resources, noise, public/emergency services, safety, socioeconomics, and water resources. The regional information included in this section provides the background for understanding the context of the site-specific information that could affect or be affected by the Proposed Action and Alternatives.

Chapter 4.0 addresses the potential effects of the Proposed Action and Alternatives on the resource areas analyzed.

Chapter 5.0 presents a list of all applicable environmental requirements relating to the Proposed Action including permits, licenses, entitlements, and regulations.

Chapters 6.0 through 9.0 identify references, persons and agencies contacted, preparers of this EA, and acronyms and abbreviations, respectively.

Appendix A contains a copy of the QRA developed to identify the preferred and alternate corridors for the proposed project. Appendix B contains the results of an air quality analysis conducted for the proposed project. The distribution list for this EA is included in Appendix C. Appendix D lists all comments received on the Draft EA along with their responses.

2.0 DESCRIPTION OF THE PROPOSED ACTION AND ALTERNATIVES

2.1 INTRODUCTION

This chapter describes the Proposed Action and Alternatives, including the No-Action Alternative. The potential environmental impacts of each alternative are summarized in table form at the end of this chapter. Alternative A, the Proposed Action, is to establish a western approach orbital reentry corridor into Edwards AFB for generic, medium size, unmanned LEVs. Alternative B is similar to Alternative A but with a northwesterly corridor. Alternative C (No-Action Alternative) is the status quo with no corridors being designated.

2.2 ALTERNATIVE IDENTIFICATION PROCESS

A two-step process was used to identify the alternatives. First, a QRA (Appendix A) was performed for all reentry azimuths between 220 degrees and 020 degrees relative to Edwards AFB extending from the approach end of Runway 22 and encompassing all land, population centers, and aircraft flight routes along each azimuth. This study analyzed the expectation of causality (E_C) at each point along the ground track and probability of aircraft impact (P_I) against the FAA and Air Force standards. The ranges of azimuths with an E_C less than or equal to 30 causalities per million missions and P_I less than 1 impact in 10 million missions were identified for further consideration. Next, the Air Force selected the corridors for Alternatives A and B for assessment under this EA based on the most probable orbital reentry track leading to the preferred landing site.

2.2.1 Preferred Landing Site Selection Criteria

The landing site is required to be a DoD or NASA flight test facility. Important selection criteria for the unmanned LEV landing site include radar tracking capabilities, test range support facilities, and range safety considerations. Landing on a hard surface provides the greatest flexibility for recovery of the unmanned LEV. Landing options include use of hard surface runways, lakebed runways, and parachute type landings to either Runway 22 or the Rogers Dry Lakebed.

2.2.2 Preferred Landing Site

Edwards AFB has historically been selected as a primary testing site for new aircraft and space vehicles because of the remote surroundings and viable landing options. The hard surface runways and the hard flat surface of the Rosamond and Rogers Dry Lakebeds have proven ideal for parachute/parasail landings and normal aircraft landings. The open terrain and lack of vertical features have contributed to the safe recovery of many test vehicles that would not have been possible in a less remote area.

Based on the selection criteria developed, AFFTC and NASA DFRC facilities at Edwards AFB provide the support facilities and flight test capabilities necessary to most effectively meet the projected test requirements for landing of a unmanned LEV. The runway length required for the LEV is between 8,000 and 12,000 feet. The primary runway at Edwards AFB is hard surfaced and is 15,000 feet long and 300 feet wide. Table 2-1 lists the additional designated lakebed runways at Edwards AFB. No new or specialized equipment would be required to support the unmanned LEV approach and landing. Current Air Force or contractor personnel from other bases would be used to handle all unmanned LEV recoveries (similar to Space Shuttle orbiter requirements).

Table 2-1
Lakebed Runways at Edwards AFB

Runways	Length (miles)
Rogers Lake	
17/35	7.5
05/23	5.2
06/24	1.4
07/25	4.0
09/270	2.0
30	2.0
15/33	6.2
18/36	4.5
Rosamond Dry Lake Bed[1]	
02/20	4.0
11/29	4.0

Note: 1- The lakebed runways at Rosamond Dry Lake Bed are not maintained or marked.

2.2.3 Generic Corridor Profile

The unmanned LEV reentry corridor is defined by the trajectory (ground track and altitude) of the vehicle as it reenters the earth's atmosphere from space. Approximately 30 minutes before touchdown, the unmanned LEV would begin entering the atmosphere at an altitude of about 400,000 feet. At approximately 45,000 feet, and within 5 miles of Edwards AFB, the unmanned LEV would maneuver to intercept the final landing approach at the desired altitude and velocity.

The unmanned LEV would make its final approach and landing using a Space Shuttle type landing pattern. As the unmanned LEV approached the Edwards AFB landing site, it would be steered to line up with the centerline of the runway.

The altitude profile of a generic trajectory is shown in Figure 2-1. The speed profile, showing the speed (in feet per second) in the vertical axis and distance from the Heading Alignment Circle (HAC) intercept (in nautical miles) in the horizontal axis, is shown in Figure 2-2.

The ground footprints for the proposed orbital reentry corridor and alternative reentry corridor are discussed in Section 2.3.

2.2.4 Existing Reentry to Landing Corridor/Procedures

Procedures for the reentry of a generic, medium-sized unmanned LEV would be similar to reentry procedures used by the Space Shuttle orbiters. Approximately 24 hours prior to reentry, NASA would notifies the FAA of an impending reentry from space. The landing procedure begins at the entry interface at an altitude of 400,000 feet above ground level [AGL], approximately 4,400 nautical miles (5,063 statute miles) from the landing site, and at a speed of 25,000 feet per second (Mach 23 [17,000 miles per hour (mph)]). At that point, the Space Shuttle Orbiter is maneuvered to level the wings and reduce the airspeed and altitude by raising the nose (increasing the angle of attack [AOA] to 40 degrees). As the Space Shuttle descends along the flight path, the speed and altitude (as depicted in Figures 2-1 and 2-2) are reduced by adjusting the vehicle's roll, pitch, and yaw. These adjustments are needed to dissipate the tremendous amounts of kinetic energy that builds up when the vehicle enters the Earth's atmosphere to

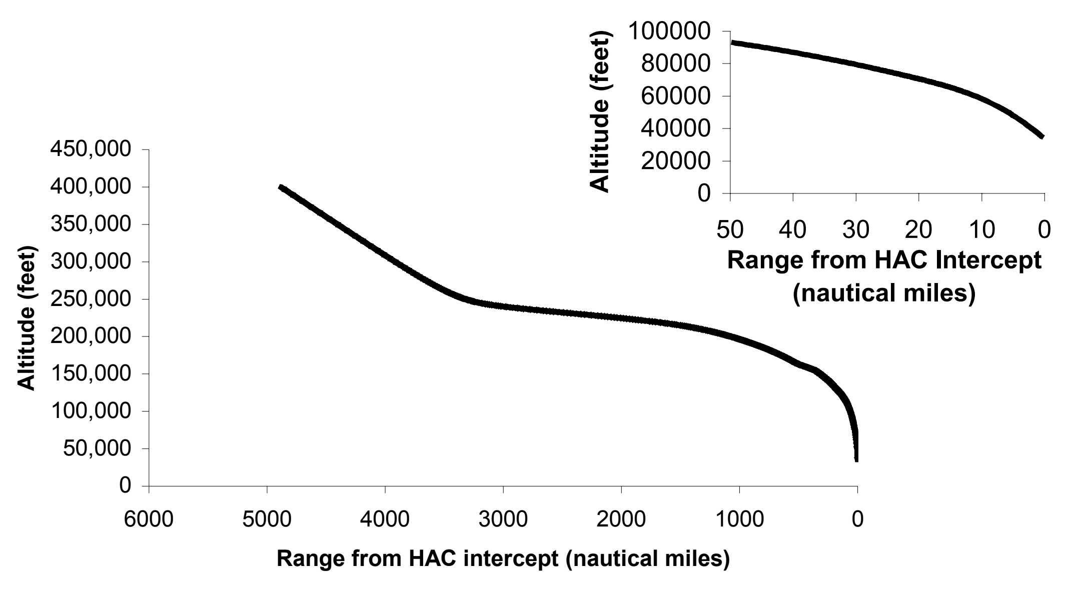


Figure 2-1 Altitude Profile of a Generic Trajectory Reentry Corridor

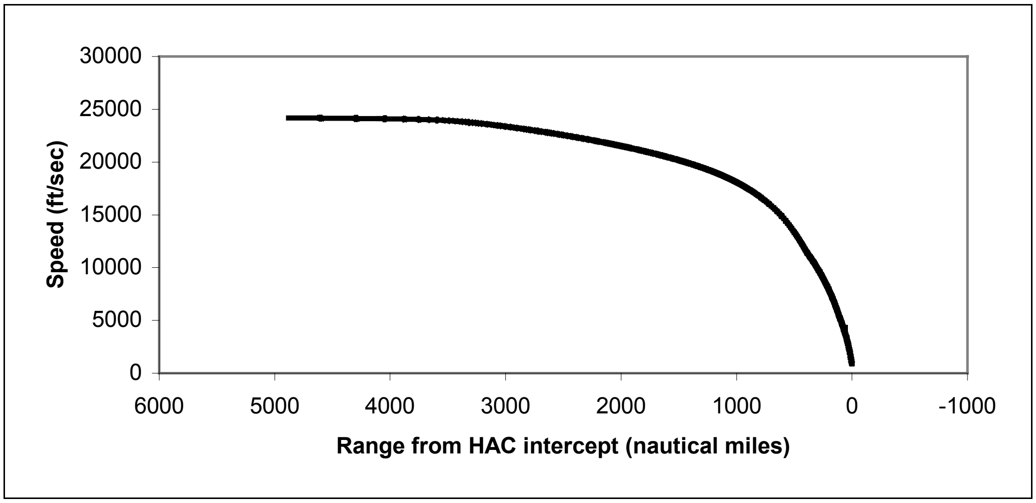


Figure 2-2 Speed Profile of a Generic Trajectory Reentry Corridor

ensure that it does not burn up (reentry angle too steep) or skip out of the atmosphere (reentry angle too shallow), and to position the vehicle to reach the desired touchdown point. If the Space Shuttle is low on energy, drag is reduced by lowering the AOA, and conversely, if the Space Shuttle has too much energy the AOA is increased. The roll angle is used to make course corrections.

The Space Shuttle transitions from the nominal 40 degrees AOA to 14 degrees AOA at 83,000 feet AGL, 2,500 feet per second (Mach 2.5 [1,850 mph]) and 52 nautical miles (59 statute miles) from the runway. At this point excess energy is reduced by making an S-turn and drag is modified by movement of other control surfaces (ailerons, elevators, and rudder).

When the Space Shuttle has descended to an altitude of 10,000 feet AGL at an approximate speed of 489 feet per second (Mach 0.45 [334 mph]), and 6.9 nautical miles (7.9 statute miles) from touchdown, autoland guidance is activated. The vehicle is guided to the minus 19- to 17- degree glide slope aimed approximately 1 mile in front of the runway. At 1,750 feet AGL the vehicle is steered to track along the runway centerline, and a preflare maneuver is started to position the vehicle on a shallow, 1.5-degree glide slope in preparation for landing. The landing gear is deployed. Final flare begins at 80 feet AGL to prevent the vehicle from landing short of the runway. The radar altimeter provides vertical guidance from 100 feet AGL to touchdown approximately 2,500 feet past the runway threshold. Final landing speed is between 309 and 315 feet per second (Mach 0.28–0.29 [211–215 mph]).

2.3 DESCRIPTION OF THE ALTERNATIVES

2.3.1 Alternative A (Western Approach)

The Western Approach Reentry Corridor is depicted in Figure 2-3. The left panel shows the corridor on a larger scale as it approaches the California coast from the west and crosses overland toward Edwards AFB; the right panel shows the same corridor near Edwards AFB.

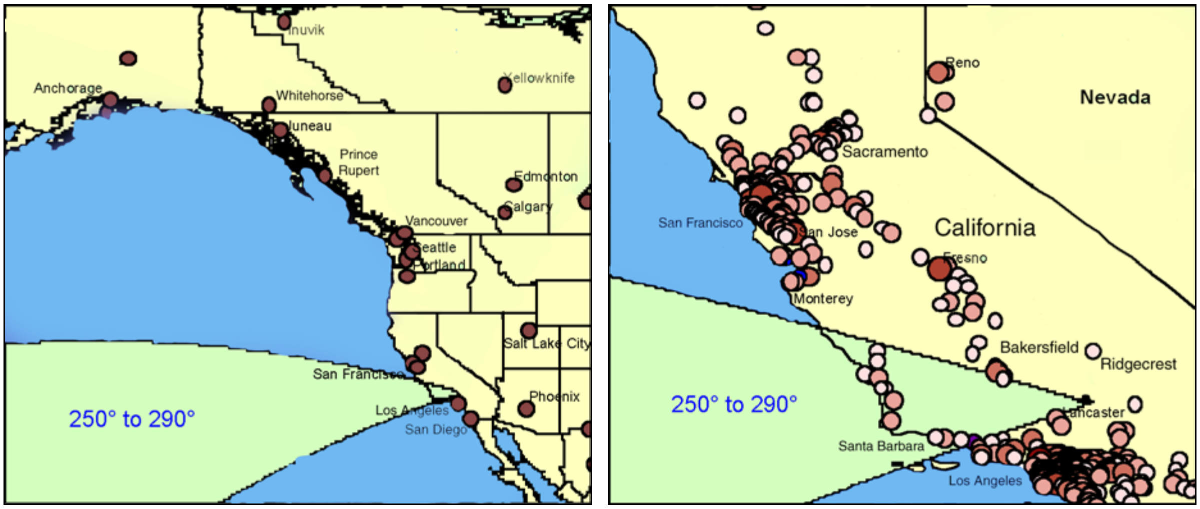

Inuvik
Anchorage
Whitehorse
Yellowknife
Juneau
Prince Rupert
Edmonton
Calgary
Vancouver
Seattle
Portland
Salt Lake City
San Francisco
Phoenix
250° to 290°
Los Angeles
San Diego
Reno
Nevada
Sacramento
San Francisco
San Jose
California
Fresno
Monterey
Bakersfield
Ridgecrest
250° to 290°
Lancaster
Santa Barbara
Los Angeles

Figure 2-3 Alternative A, Western Approach Orbital Reentry Corridor

The Western Approach Reentry Corridor would be approximately 140 nautical miles wide crossing the California coast, and would include that airspace extending from the HAC intercept point at 34 degrees 54 minutes north latitude, 117 degrees 40 minutes west longitude extending along the 250-degree radial crossing the coastline at 34 degrees 21 minutes north latitude, 119 degrees 25 minutes west longitude, and along the 290-degree radial crossing the coastline at 35 degrees 57 minutes north latitude and 121 degrees 27 minutes west longitude. The unmanned LEV would cross the coastline at an elevation of approximately 108,000 feet above msl.

2.3.2 Alternative B (Northwestern Approach)

The Northwestern Approach Reentry Corridor is depicted in Figure 2-4. The left panel shows the corridor on a larger scale as it approaches the Pacific Northwest coast, and the right panel shows the same corridor approaching Edwards AFB from the northwest after the vehicle has entered the airspace over California. This corridor would be approximately 240 nautical miles wide as it crosses the California/Oregon coast. It extends from the HAC intercept point at 34 degrees 54 minutes north latitude, 117 degrees 40 minutes west longitude along the 325-degree radial crossing the California coast at 41 degrees 38 minutes north latitude, 124 degrees 06 minutes west longitude, and along the 337-degree radial, crossing the Oregon coast at 45 degrees 58 minutes north latitude, 123 degrees 56 minutes west longitude. The unmanned LEV would cross the coastline at an elevation of approximately 160,000 feet above msl.

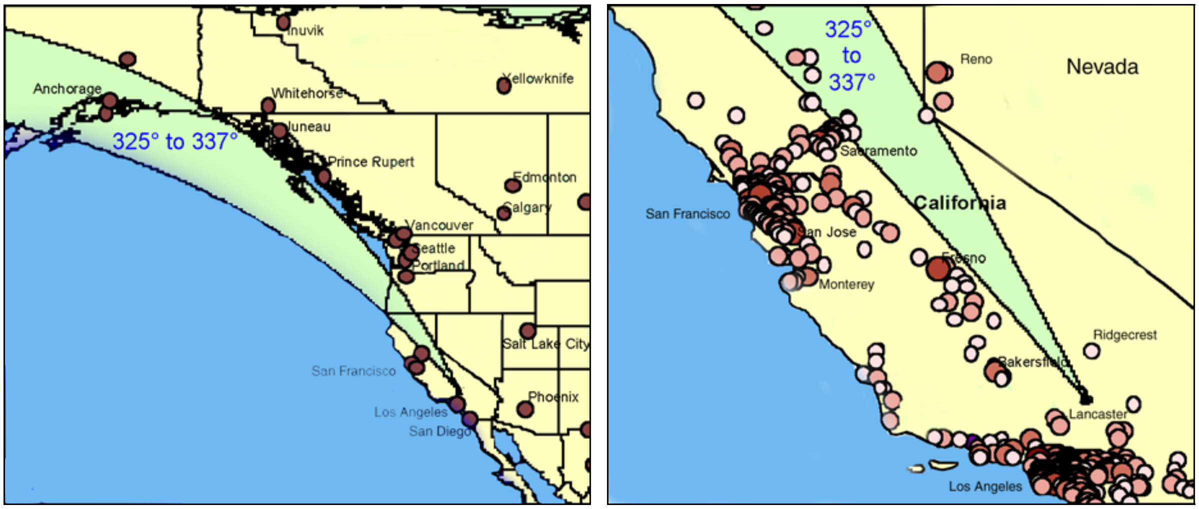

Inuvik
Yellowknife
Anchorage
Whitehorse
Juneau
325° to 337°
Prince Rupert
Edmonton
Calgary
Vancouver
Seattle
Portland
Salt Lake City
San Francisco
Phoenix
Los Angeles
San Diego
325° to 337°
Reno
Nevada
Sacramento
San Francisco
California
San Jose
Fresno
Monterey
Ridgecrest
Bakersfield
Lancaster
Los Angeles

Figure 2-4 Alternative B, Northwestern Approach Orbital Reentry Corridor

2.3.3 Alternative C (No-Action Alternative)

Under the No-Action Alternative an orbital reentry corridor for unmanned LEVs would not be established at Edwards AFB, California.

2.3.4 Alternatives Considered and Dismissed From Further Consideration

The CEQ regulations require that NEPA documents evaluate all reasonable alternatives, briefly discuss alternatives eliminated from detailed analysis, and provide the reasons for elimination of any alternatives (40 CFR 1502.14[a]). “Reasonable is defined as practical or feasible from a common sense, technical, and economic standpoint” (51 *Federal Register* 15618, April 25, 1986).

A wide range of entry azimuths, 220 degrees to 020 degrees, from just north of the Los Angeles basin to east of Ridgecrest, California, were considered and evaluated in a QRA (Appendix A). The risk analysis quantified risks to persons, property, and aircraft from the return from orbit and descent of an unmanned LEV. Estimated failure rates, unmanned LEV breakup characteristics, trajectory modeling, and seasonal atmospheric variations (atmospheric density and wind modeling), population distribution and sheltering characteristics, and air traffic (aircraft density) modeling, were used to provide a risk assessment of alternative entry corridors.

The risk analysis indicated that entry corridors over the Los Angeles basin (with azimuths of between 220 and 249 degrees) and over Bakersfield, San Francisco, Stockton, and Fresno (with azimuths between 295 and 325 degrees) had higher risk than the preferred corridors. Using the estimated vehicle reliability for an experimental unmanned LEV, risks associated with these corridors would exceed the expectation of casualty standards established by the Air Force or FAA (AFFTC 2001). Consequently, consideration of additional entry corridors along those azimuths was eliminated, although they could be potential reentry corridors for a future, high reliability, operational unmanned LEV.

The risk analysis also identified azimuths from 350 degrees to 020 degrees as acceptable trajectories for reentry from polar orbit, however, these azimuths were not evaluated as part of this EA because a polar orbit reentry corridor would not normally be considered as a primary corridor for an experimental unmanned LEV.

2.4 OTHER FUTURE ACTIONS IN THE REGION

Other actions within the region were evaluated to determine whether cumulative environmental impacts could result from implementation of the Proposed Action and Alternatives. Cumulative impacts result from "the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time" (40 CFR 1508.7).

Other actions within the geographic region of Edwards AFB and the R-2508/R-2515 special use airspace that could be considered to have the potential for cumulative effects include other flight test programs. However, because appropriate range safety requirements are in place to ensure a safe environment to conduct flight tests, along with coordination with the FAA, these actions are not expected to have cumulative impacts.

2.5 COMPARISON OF ENVIRONMENTAL IMPACTS

Table 2-2 presents a summary of anticipated environmental impacts for each alternative.

Table 2-2
Anticipated Environmental Impacts for the Affected Environment

Issues	Alternative A	Alternative B	Alternative C
Air Quality	Less than significant	Less than significant	None
Air Space	Less than significant	Less than significant	None
Cultural Resources	No impacts	No impacts	None
Environmental Justice	No impacts	No impacts	None
Geology and Soils	Less than significant	Less than significant	None
Hazardous Waste/Hazardous Materials	No impacts	No impacts	None
Infrastructure	No impacts	No impacts	None
Land Use	No impacts	No impacts	None
Natural Resources	Less than significant	Less than significant	None
Noise	No impacts	No impacts	None
Public/Emergency Services	No impacts	No impacts	None
Safety	Less than significant	Less than significant	None
Socioeconomics	No impacts	No impacts	None
Water Resources	No impacts	No impacts	None

3.0 AFFECTED ENVIRONMENT

This chapter describes existing environmental conditions likely to be affected by Alternatives A, B, and C. The Region of Influence (ROI) consists of Edwards AFB and all areas within the azimuth range for Alternatives A and B. The ROI for each action will be discussed in terms of two distinct regions: (1) on-base region, and (2) off-base region. The on-base region includes all of Edwards AFB. The off-base region includes all areas within the western approach entry corridor, within an azimuth range of 250 to 290 degrees (Alternative A), and all areas within the northwestern approach entry corridor, within an azimuth range of 325 to 337 degrees (Alternative B). Azimuths are drawn from Runway 22 on Edwards AFB. Alternative C is the No-Action Alternative.

Resources within the ROI have been identified under the following categories: air quality, airspace, cultural resources, environmental justice, geology and soils, hazardous waste/hazardous materials, infrastructure, land use, natural resources, noise, public/emergency services, safety, socioeconomics, and water resources.

3.1 AIR QUALITY

Air quality in a given location is defined by the concentration of various pollutants in the atmosphere, generally expressed as parts per million (ppm) or micrograms per cubic meter ($\mu g/m^3$). The significance of a pollutant concentration is determined by comparing it to federal and/or state ambient air quality standards. These standards represent the maximum allowable atmospheric concentrations that may occur and still protect public health and welfare with a reasonable margin of safety. The federal standards are established by the U.S. Environmental Protection Agency (U.S. EPA) and termed the National Ambient Air Quality Standards (NAAQS). The NAAQS are defined as the maximum acceptable ground-level concentrations that may not be exceeded more than once per year, except for annual standards, which may never be exceeded. These standards include concentrations for ozone, carbon monoxide (CO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), particulate matter 10 microns or less in diameter (PM_{10}) and 2.5 microns or less in diameter ($PM_{2.5}$), and lead. The California Air Resources Board (CARB) has established state standards termed the California Ambient Air Quality Standards (CAAQS). The CAAQS are at least as restrictive as the NAAQS and include pollutants for which there are no national standards. The national and state ambient air quality standards are shown in Table 3-1.

The pollutants considered in the impact analysis of this EA include volatile organic compounds (VOCs), ozone, CO, nitrogen oxides (NO_x), NO_2, SO_2, and PM_{10}. Airborne emissions of lead are not considered in this EA, since there are no known significant sources of lead associated with the proposed project. Nitrogen oxides and VOCs are of particular concern since they are precursor emissions that form ozone.

Ozone concentrations are generally highest during the summer and coincide with the period of maximum insolation (the maximum amount of solar radiation striking the earth's surface). Maximum ozone concentrations tend to be regionally distributed, since precursor emissions become homogeneously dispersed in the atmosphere. Concentrations of inert pollutants, such as CO, tend to be the greatest during the cooler months of the year and are often a product of light wind conditions and nighttime/early morning surface-based inversions. Maximum inert pollutant concentrations are usually found near an emission source.

Evaluating impacts to air quality in the ROI requires knowledge of (1) the types of pollutants being emitted, (2) emission rates of the pollutant source, (3) the proximity of project emission sources to other emission sources, (4) topography, and (5) local and regional meteorological conditions. The area of effect

Table 3-1
National and California Ambient Air Quality Standards

			National Standards[a]	
Pollutant	**Averaging Time**	**California Standards**	**Primary[b,c]**	**Secondary[b,d]**
Ozone	1-hour	0.09 ppm (180 $\mu g/m^3$)	0.12 ppm (235 $\mu g/m^3$)	Same as primary
	8-hour	---	0.008 ppm	---
Carbon monoxide	8-hour	9 ppm (10 mg/m^3)	9 ppm (10mg/m^3)	---
	1-hour	20 ppm (23 mg/m^3)	35 ppm (40 mg/m^3)	---
Nitrogen dioxide	Annual	---	0.053 ppm 100 ($\mu g/m^3$)	Same as primary
	1-hour	0.25 ppm (470 $\mu g/m^3$)	---	---
Sulfur dioxide	Annual	---	0.03 ppm (80 $\mu g/m^3$)	---
	24-hour	0.04 ppm (105 mg/m^3)	0.14 ppm (365 $\mu g/m^3$)	---
	3-hour	---	---	0.5 ppm (1,300 $\mu g/m^3$)
	1-hour	0.25 ppm (655 $\mu g/m^3$)	---	---
PM_{10}	Annual (arithmetic mean)	---	50 $\mu g/m^3$	Same as primary
	Annual (geometric mean)	30 $\mu g/m^3$	---	---
	24-hour	50 $\mu g/m^3$	150 $\mu g/m^3$	Same as primary
$PM_{2.5}$(e)	Annual arithmetic	---	15 $\mu g/m^3$	Same as primary
	24-hour	---	65 $\mu g/m^3$	Same as primary
Lead	Calendar quarter	---	1.5 $\mu g/m^3$	Same as primary
	30-day average	1.5 $\mu g/m^3$	---	---

Notes: a – Other than for ozone and those based upon annual averages, standards are not to be exceeded more than once per year. The ozone standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above the standard is equal to or less than one.

b – Concentrations are expressed first in the units in which they were promulgated. Equivalent units given in parentheses.

c – Primary Standards: The level s of air quality necessary, with an adequate margin of safety, to protect the public health. Each state must attain the primary standards no later than 3 years after the state's implementation plan is approved by the EPA.

d – Secondary Standards: The levels of air quality necessary to protect the public welfare from any known or anticipated adverse effects of a pollutant. Each state must attain the secondary standards within a "reasonable time" after the EPA approves the implementation plan.

EPA - Environmental Protection Agency
$\mu g/m^3$ – micrograms per cubic meter
mg/m^3 – milligrams per cubic meter
$PM_{2.5}$ –particulate mater equal to or less than 2.5 microns in diameter
PM_{10} –particulate mater equal to or less than 10 microns in diameter
ppm - parts per million

for emissions of inert pollutants (pollutants other than ozone and its precursors) is generally limited to a few miles downwind from the source. The area of effect for ozone generally extends much further downwind than the area of effect for inert pollutants. In the presence of solar radiation, the maximum effect of precursor emissions on ozone levels usually occurs several hours after their release and, therefore, many miles from the source.

The U.S. EPA designates all areas of the United States as having air quality better than (attainment) or worse than (non-attainment) the NAAQS. The criteria for non-attainment designation vary by pollutant: (1) an area is in non-attainment for ozone if its NAAQS has been exceeded more than three discontinuous times in 3 years at a single monitoring station, and (2) an area is in non-attainment for any other pollutant if its NAAQS has been exceeded more than once per year. Pollutants in an area are often designated as unclassified when there are insufficient ambient air quality data for the U.S. EPA to form a basis for attainment status. The CARB considers an area to be in non-attainment of a CAAQS for a particular pollutant if: (1) the standards for ozone, CO (except Lake Tahoe), SO_2 (1 and 24 hour), NO_2, PM_{10}, and visibility reducing particles have been exceeded; or (2) the remaining pollutants have been equaled or exceeded.

Air quality regulations were first promulgated with the federal Clean Air Act (CAA). This Act established the NAAQS and delegated the enforcement of air pollution regulations to the states. In areas where the NAAQS are exceeded, the CAA requires preparation of a State Implementation Plan (SIP), which describes how a state will attain the standards within mandated time frames. The CAA Amendments revised the attainment planning process. The requirements and compliance dates for reaching attainment are based upon the severity of the air quality standard violation.

The CAA states that a federal agency cannot support an activity unless the agency determines that the activity will conform to the most recent U.S. EPA-approved SIP within the region of the proposed action. This means that federally supported or funded activities will not (1) cause or contribute to any new air quality standard violation, (2) increase the frequency or severity of any existing standard violation, or (3) delay the timely attainment of any standard or any required interim emission reductions or other milestones in any area. Ongoing activities are exempt from this rule as long as there is no increase in emissions above the *de minimis* levels specified in the rule. Table 3-2 presents the *de minimis* threshold level of non-attainment areas.

In addition to meeting *de minimis* requirements, a federal action must not be considered a regionally significant action. A federal action is considered regionally significant when the total emissions from the action equal or exceed 10 percent of the air quality control area's emissions inventory for any criteria pollutant.

If a federal action meets *de minimis* requirements and is not considered a regionally significant action, it is exempt from further conformity analyses pursuant to 40 CFR Part 93.153. If the proposed action is modified in the future, or if attainment areas are reclassified based on the new NAAQS or monitoring data, a revision to the conformity analysis may be required for those areas.

The impact on visibility from air pollutant emission sources is an issue with regard to federally mandated Class 1 areas, such as national parks and wilderness areas, where any appreciable deterioration in air quality is considered significant. The R-2508 Complex includes Class 1 areas at Death Valley National Park, Sequoia National Park, Kings Canyon National Park, and the Domeland National Wilderness Area (Figure 3-1).

Table 3-2
***De minimis* Thresholds in Non-attainment Areas**

Pollutant	Degree of Non-attainment	*De minimis* Level (tons/year)
Ozone (VOCs and NO_x)	Serious	50
	Severe	25
	Extreme	10
	Marginal and Moderate (outside an ozone transport region)	100
	Marginal and Moderate (inside an ozone transport region)	50 (VOC) 100 (NO_x)
CO	All	100
Particulate Matter	Moderate	100
	Serious	70
SO_2 or NO_2	All	100
Lead	All	25

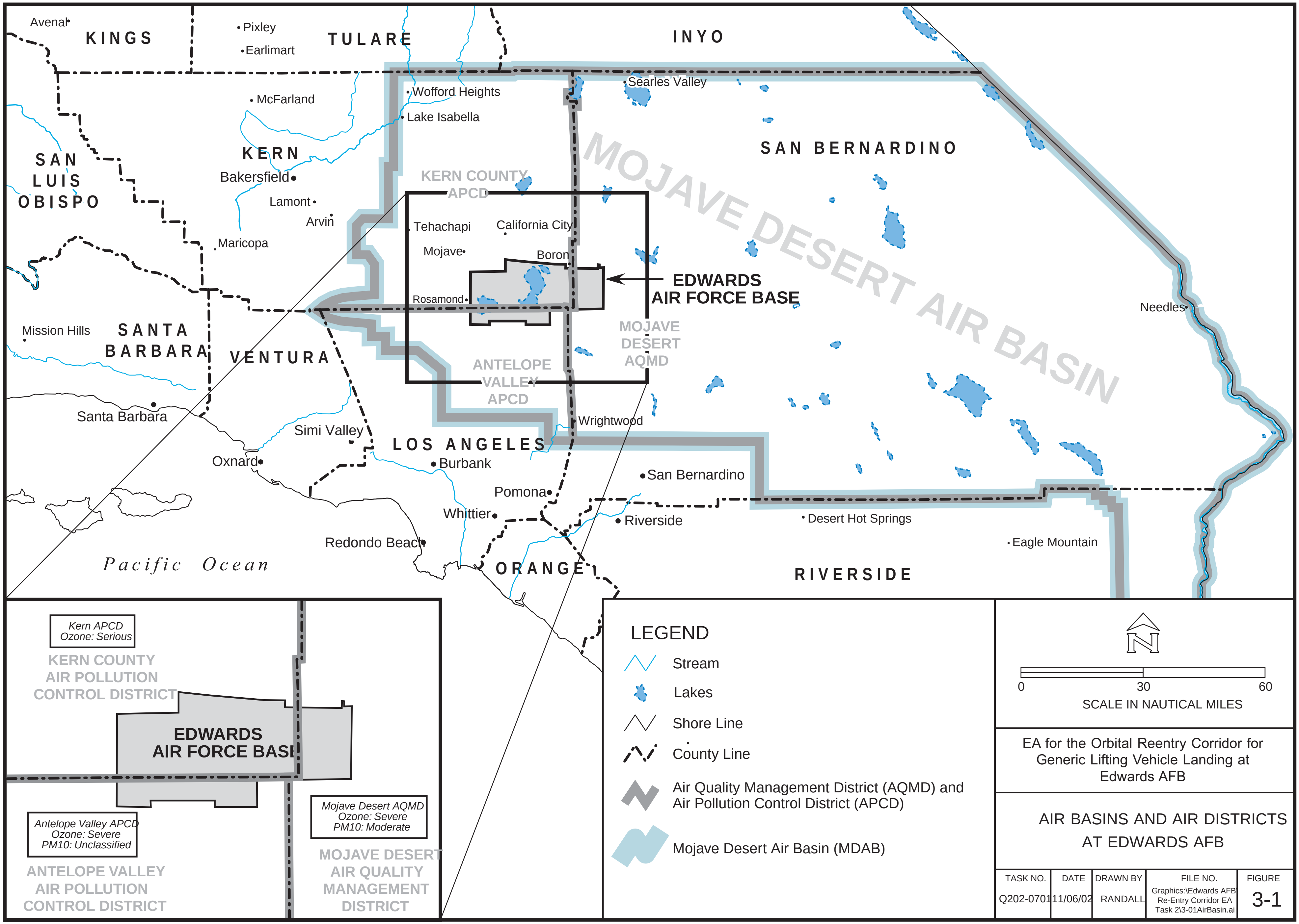
Notes:
CO - carbon monoxide
NO_2 - nitrogen dioxide
NO_x - nitrogen oxides
SO_2 - sulfur dioxide
VOC - volatile organic compound

Areas in attainment with the NAAQS are regulated under the Prevention of Significant Deterioration (PSD) program authorized by the CAA Part C, Sections 160–169. PSD areas require that owners and/or operators of new or modified sources obtain a PSD permit prior to construction of a major source (40 CFR Part 5221) in attainment or unclassified areas. A major source is defined by PSD regulations as being a specific type of source listed by the U.S. EPA that has a potential of emitting 100 tons per year of a regulated pollutant. Potential to emit is based on the maximum design capacity of a source and takes into account pollution control efficiency. If the U.S. EPA does not list a source, it may still be considered major if it has the potential to emit 250 tons per year of a regulated pollutant.

3.1.1 On-Base Region

The following sections provide a description of the climate, baseline air quality and emissions, and regulatory setting for Edwards AFB. The affected environment for air quality would be identical under both Alternatives A and B. Edwards AFB extends into Kern, San Bernardino, and Los Angeles Counties within the Mojave Desert Air Basin (MDAB) of eastern California and is located within the jurisdiction of three local air districts: Kern County Air Pollution Control District (KCAPCD), Mojave Desert Air Quality Management District, and Antelope Valley Air Pollution Control District as shown in Figure 3-1.

The main base at Edwards AFB is located in the eastern portion of Kern County, which is under the jurisdiction of the KCAPCD. Since all of the activities under the proposed project that could impact air quality occur on the main base, discussions of environmental effects to air quality are analyzed in relation to baseline air quality in the KCAPCD.


Avenal
KINGS
Pixley
Earlimart
TULARE
INYO
Searles Valley
Wofford Heights
Lake Isabella
McFarland
SAN LUIS OBISPO
KERN
Bakersfield
Lamont
Arvin
Maricopa
KERN COUNTY APCD
MOJAVE DESERT AIR BASIN
SAN BERNARDINO
Tehachapi
California City
Mojave
Boron
Rosamond
EDWARDS AIR FORCE BASE
Needles
MOJAVE DESERT AQMD
Mission Hills
SANTA BARBARA
VENTURA
ANTELOPE VALLEY APCD
Santa Barbara
Wrightwood
Simi Valley
LOS ANGELES
Oxnard
Burbank
San Bernardino
Pomona
Whittier
Riverside
Desert Hot Springs
Eagle Mountain
Redondo Beach
Pacific Ocean
ORANGE
RIVERSIDE
Kern APCD
Ozone: Serious
KERN COUNTY AIR POLLUTION CONTROL DISTRICT
EDWARDS AIR FORCE BASE
Antelope Valley APCD
Ozone: Severe
PM10: Unclassified
ANTELOPE VALLEY AIR POLLUTION CONTROL DISTRICT
Mojave Desert AQMD
Ozone: Severe
PM10: Moderate
MOJAVE DESERT AIR QUALITY MANAGEMENT DISTRICT
LEGEND
Stream
Lakes
Shore Line
County Line
Air Quality Management District (AQMD) and Air Pollution Control District (APCD)
Mojave Desert Air Basin (MDAB)
N
0
30
60
SCALE IN NAUTICAL MILES

EA for the Orbital Reentry Corridor for
Generic Lifting Vehicle Landing at
Edwards AFB

AIR BASINS AND AIR DISTRICTS
AT EDWARDS AFB

TASK NO.	DATE	DRAWN BY	FILE NO.	FIGURE
Q202-0701	11/06/02	RANDALL	Graphics:\Edwards AFB\ Re-Entry Corridor EA Task 2\3-01AirBasin.ai	3-1

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Climate

Hot summers, cool winters, low rainfall, large diurnal ranges in temperature, and abundant sunshine characterize the climate at Edwards AFB. The aridity of the region is mainly due to the rainshadow effects of the Sierra Nevada and San Gabriel Mountains, where the prevailing westerly winds deposit most of their moisture on the western slopes of these mountain ranges. Data collected at Edwards AFB from 1979 to 1989 are used to describe the climate of the project region (National Oceanic and Atmospheric Administration 2001).

The dominant weather feature in the project region is the Eastern Pacific high-pressure system. This system is most prevalent during the summer, when it occupies a northern position over the Pacific Ocean. Concurrent with the presence of high pressure, a low-level, thermal low-pressure system persists over the desert regions due to intense surface heating. The relative strengths and positions of the high-pressure system and the interior thermal trough are largely responsible for the general climatic conditions of the region.

Precipitation

During the winter, the Eastern Pacific high-pressure system weakens and moves southward, allowing polar storm systems to migrate through the region. Although the systems that reach the region have dried out considerably after traversing the elevated terrain to the west, they are responsible for most of the annual precipitation in the area. The average annual precipitation at Edwards AFB is 4.9 inches. Rainfall during the summer usually occurs from thunderstorms. Moisture from these storms originates from tropical air masses that move into the region from the south-southeast. Snow can occur in the region, although the average total is only about 2 inches per year.

Temperature

The annual average temperature at Edwards AFB is 62 degrees Fahrenheit (°F). Daily mean high and low temperatures for January are 57°F and 31°F, respectively. Daily mean high and low temperatures for July are 98°F and 66°F, respectively. Extreme temperatures that occurred during a 10-year monitoring period ranged from 4°F to 113°F.

Prevailing Winds

The combination of the Eastern Pacific high-pressure system over the Pacific Ocean and the thermal low over the interior desert produces a prevailing southwest wind in the region. Strong winds occur during the spring and summer, when the pressure gradient between the offshore Pacific High and the interior thermal trough is the greatest. However, extreme wind gusts can also occur with thunderstorms. Calm conditions increase during the fall and winter, when cold continental air replaces the thermal low and produces weak pressure gradients.

Baseline Air Quality and Emissions

The MDAB is impacted by both ozone and fugitive dust emissions. Table 3-3 presents a summary of the attainment status of the project area in California. These data show that the majority of the region is in non-attainment of the state and national standards for ozone and PM_{10} and in attainment or unclassified for CO_2, NO_2, and SO_2 ambient air quality standards. With regard to the NAAQS, Edwards AFB is designated as a “serious” ozone non-attainment area and is in attainment or unclassified for all other pollutants.

Table 3-3
National/California Ambient Air Quality Standards Attainment Designations for the Project Area

County/Air Basin	Ozone	CO	NO_2	SO_2	PM_{10}
Kern/MDAB[a]	N/N	U*/U	U*/A	U/A	U*, N/N
San Bernardino/MDAB[b]	A, N/N	U*/A	U*/A	U/A	N/N
Antelope Valley/MDAB	N/N	U*/A	U*/A	U/A	U/N

Notes: Designation status: A= attainment, N= non-attainment, U= unclassified, and U*/A= unclassified/attainment.

a – With regard to the NAAQS for PM_{10} the entire county within the MDAB is unclassified/attainment for the federal standard, except the Searles Valley Planning Area, which is in non-attainment.

b – With regard to the NAAQS for ozone, the western portion of San Bernardino County within the MDAB is in non-attainment, and the eastern portion is in attainment.

CO – carbon monoxide
MDAB – Mojave Desert Air Basin
NO_2 – nitrogen dioxide
PM_{10} – particulate matter equal to or less than 10 microns in diameter
SO_2 – sulfur dioxide

Source: California Environmental Protection Agency, Air Resources Board 2000.

Eastern Kern County is located on the western edge of the Mojave Desert and is separated from populated valleys and coastal areas to the west and south by several mountain ranges. These valleys and coastal areas are the major source of ozone precursor emissions affecting ozone exceedances within Kern County's part of the MDAB. Although the sources of pollution in eastern Kern County do not by themselves result in exceedances of the federal ozone standards, this region is largely impacted by ozone transport from both the San Joaquin Valley Air Basin and the South Coast Air Basin.

Elevated levels of PM_{10} are primarily associated with fugitive dust, which is produced through a combination of high winds, dry soil conditions resulting from an arid climate, and ground-disturbing activities such as mining, agriculture, and construction.

Regulatory Setting

In California, the CARB is responsible for enforcing air pollution regulations. The CARB has, in turn, delegated the responsibility of regulating stationary emission sources to local air agencies. There are no stationary sources of emissions associated with the proposed project. This area is within the eastern portion of Kern County, which is part of the MDAB. Therefore, the analysis will include only the portion of Kern County within the MDAB. Inflight aircraft emissions over 3,000 feet AGL are generally unregulated within the project region, and are not considered for planning purposes.

The KCAPCD has prepared three planning documents to demonstrate attainment of the NAAQS for ozone in the MDAB portion of Kern County: (1) a *1993 Rate-of Progress Plan* (KCAPCD 1993), (2) a *Reasonable Further Progress Plan* (KCAPCD 1994a), and (3) an *Attainment Demonstration Plan* (KCAPCD 1994b). These three attainment plans have been approved by the U.S. EPA and are included in the California ozone SIP. These documents outline baseline and future regional emission inventories, mandated emission reductions, and a demonstration by computer modeling that the federal ozone standard would be attained by 1999. Local air agencies within the remainder of the project region have also produced plans to attain the NAAQS. Project emissions within these areas would occur mainly from inflight aircraft.

Table 3-4 provides a summary of aircraft emissions at Edwards AFB in 1997 for comparison to the flights associated with the Generic Lifting Entry Vehicle Corridor Project. These baseline emissions for the upper atmosphere within the airspace at Edwards AFB are based on approximately 54,000 sorties (flights) annually.

Table 3-4
Summary of Existing Aircraft Emissions at Edwards AFB (tons/year)

VOC	CO	NO_x	SO_2	PM_{10}
219.5	488.3	350.9	32.9	26.5

Notes: Represents emissions that occurred in 1996 (U.S. Air Force 1997b).
CO - carbon monoxide
NO_x - nitrogen oxides
PM_{10} - particulate matter 10 microns or less in diameter
SO_2 - sulfur dioxide
VOC - volatile organic compound

Edwards AFB is situated in the MDAB portion of Kern County. Current and forecasted baseline emissions for this portion of Kern County are listed in Table 3-5.

Table 3-5
Kern County (Mojave Desert Air Basin Portion) Emission
Baseline and Forecasted Emission Baseline (tons/year)

Year	VOC	NO_x	PM_{10}
1990[a]	6,022.5	NA	25,548
1996[b]	4,945.7	14,231.3	17,328[c]
1999[b]	4,978.6	14,811.70	NA

Notes: a - Actual
b - Estimated
c - PM_{10} estimated for 1994.
NA - not available
NO_x - nitrogen oxides
PM_{10} - particulate matter 10 microns or less in diameter
VOC - volatile organic compound

Sources: KCAPCD 1993, 1994a, 1996c, 1997d.

3.1.2 Off-Base Region

Since there would be no sources of emissions generated off-base under the proposed project, off-base air quality would not be impacted.

3.2 AIRSPACE

Airspace is defined as the space that lies above a nation and comes under its jurisdiction. Although it is generally viewed as being unlimited, airspace is a finite resource that can be defined vertically and horizontally, as well as temporally, when describing its use for aviation purposes. Under Public Law 85-725, the FAA is charged with the safe and efficient use of the nation's airspace and has therefore established certain criteria and limits for its use. In order to accomplish its task, the FAA utilizes the National Airspace System (NAS). NAS is "...a common network of U.S. airspace; air navigation facilities, equipment and services, airports or landing areas; aeronautical charts, information and services; and rules, regulations and procedures, technical information and manpower and material" (Jeppesen Sanderson, Incorporated 2000).

The affected environment for this section, therefore, includes all airspace within Alternative A and Alternative B, and is described in terms of its principal attributes: controlled and uncontrolled airspace, special use airspace, military training routes, en route airways and jet routes, airports and airfields, and air traffic control (ATC).

Within the United States, the FAA classifies airspace as either controlled or uncontrolled. Controlled airspace is an airspace within which ATC service is provided to instrument flight rules (IFR) flights and visual flight rules (VFR) flights in accordance with a specific airspace classification (Class A, B, C, D, or E). Within controlled airspace, all aircraft operators are subject to certain pilot qualifications, operating rules, and equipment requirements (Illman 1993). Uncontrolled airspace (Class G) is an airspace that is not classified by the FAA. Figure 3-2 depicts the classes of airspace controlled by the FAA.

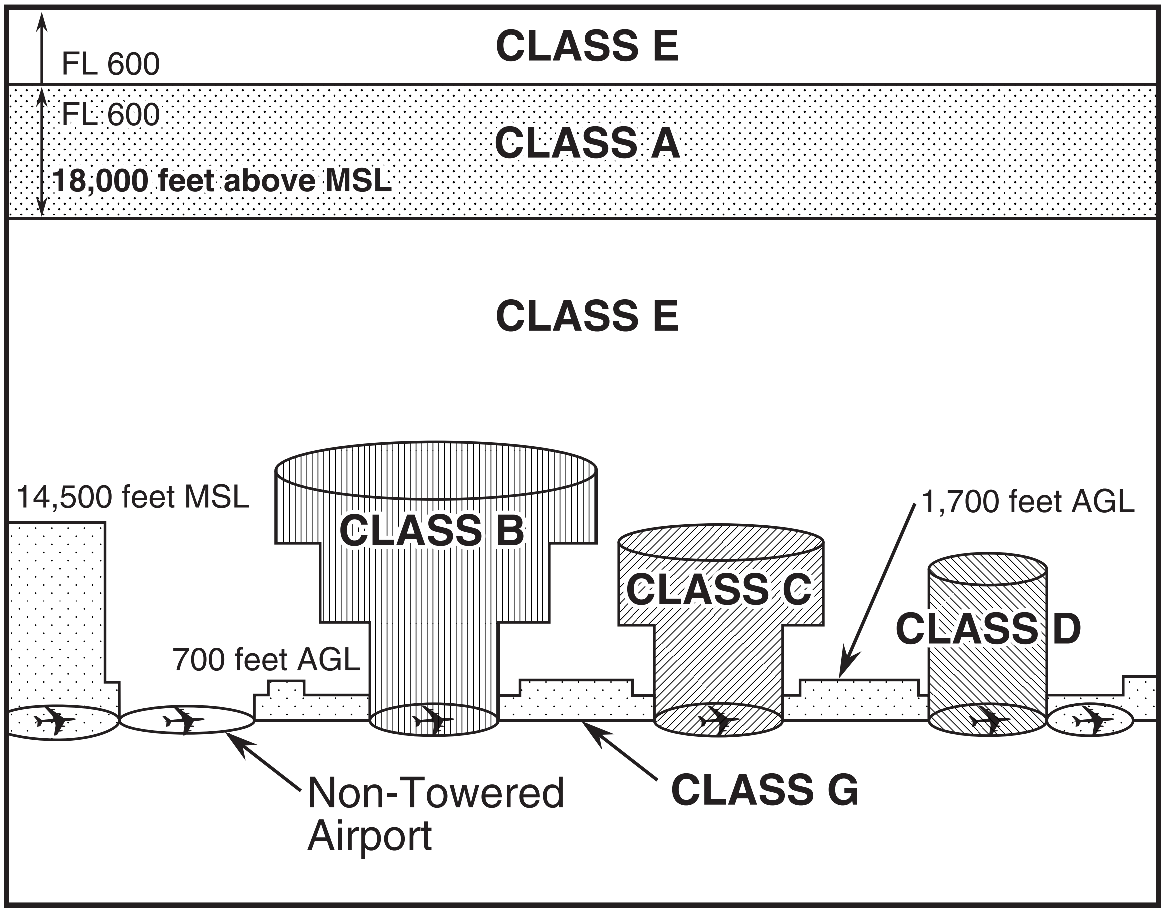
Class A airspace is airspace of the United States, including that airspace overlying the waters within 12 nautical miles of the coast of the 48 contiguous states, from 5,486 meters (18,000 feet) above msl up to and including flight level (FL)600 (18,288 meters or 60,000 feet above msl) excluding the states of Alaska and Hawaii, Santa Barbara Island, Farallon Island, and the airspace south of latitude 25 degrees 04 minutes 00 seconds North.

Class B airspace generally ranges from the surface to 10,000 feet above msl surrounding the nation's busiest airports in terms of IFR operations or passenger enplanements. The configuration of each Class B airspace is individually tailored and consists of a surface area and two or more layers, and is designed to contain all published instrument procedures once an aircraft enters the airspace.

Class C airspace generally ranges from the surface to 4,000 feet above the airport elevation and surrounding those airports that have an operational control tower, that are serviced by a radar approach control, and that have a certain number of IFR operations or passenger enplanements. Although the configuration of each Class C airspace area is individually tailored, the airspace usually consists of a surface area with a 5 nautical mile radius, and an outer circle with a 10 nautical mile radius that extends from 1,200 feet to 4,000 feet above the airport elevation.

Class D airspace generally ranges from the surface to 2,500 feet above the airport elevation and surrounding those airports that have an operational control tower. The configuration of each Class D airspace area is individually tailored and when instrument procedures are published, the airspace will normally be designed to contain the procedures.

Class E airspace is generally defined as any controlled airspace that is not Class A, B, C, or D and includes uncontrolled airspace above FL 600. Class E airspace extends upward from either the surface or a designated altitude to the overlying or adjacent controlled airspace. When designated as a surface area, the airspace will be configured to contain all instrument procedures. Also in this class are federal airways, airspace beginning at either 700 or 1,200 feet AGL, used to transition to and from the terminal or en route environment, en route domestic, and offshore airspace areas designated below 18,000 feet above msl. Unless designated at a lower altitude, Class E airspace ranges from 14,500 feet above msl up to but not including 18,000 feet above msl, including the airspace overlying the waters within 12 nautical miles of the coast of the 48 contiguous states and Alaska.


CLASS E
FL 600
FL 600
CLASS A
18,000 feet above MSL
CLASS E
14,500 feet MSL
CLASS B
1,700 feet AGL
CLASS C
CLASS D
700 feet AGL
Non-Towered Airport
CLASS G

LEGEND

░ Class A
▥ Class B
▨ Class C
▧ Class D
☐ Class E
░ Class G

✈ Airport
FL Flight Level
MSL Mean Sea Level
AGL Above Ground Level

EA for the Orbital Reentry Corridor for
Generic Unmanned Lifting Entry Vehicle
Landing at Edwards AFB

FAA CLASSES OF CONTROLLED AND UNCONTROLLED AIR SPACE

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TASK NO.	DATE	DRAWN BY	AI FILE NO.	FIGURE NO.
Q202-0701	11/6/02	RANDALL	Graphic:\ EdwardsAFB\ Rentry\3-2 Diagram.ai	3-2

3.2.1 Alternative A (Western Approach)

3.2.1.1 Controlled and Uncontrolled Airspace

Other than the special use airspace identified below (see Section 3.2.1.2), all airspace within Alternative A is Class A, Class C, Class D, or Class E controlled airspace, within which some or all aircraft may be subject to ATC. Within Class E airspace, separation service is provided for IFR aircraft only, and to the extent practical, traffic advisories are provided for aircraft operating under VFR. The Class E airspace has a floor of 1,200 feet or greater above the surface, except for the areas around the numerous airports within Alternative A, where the Class E airspace has a floor of 700 feet above the surface. There is no Class B airspace within Alternative A. All airspace above FL 600 is uncontrolled (Class E) airspace.

3.2.1.2 Special Use Airspace

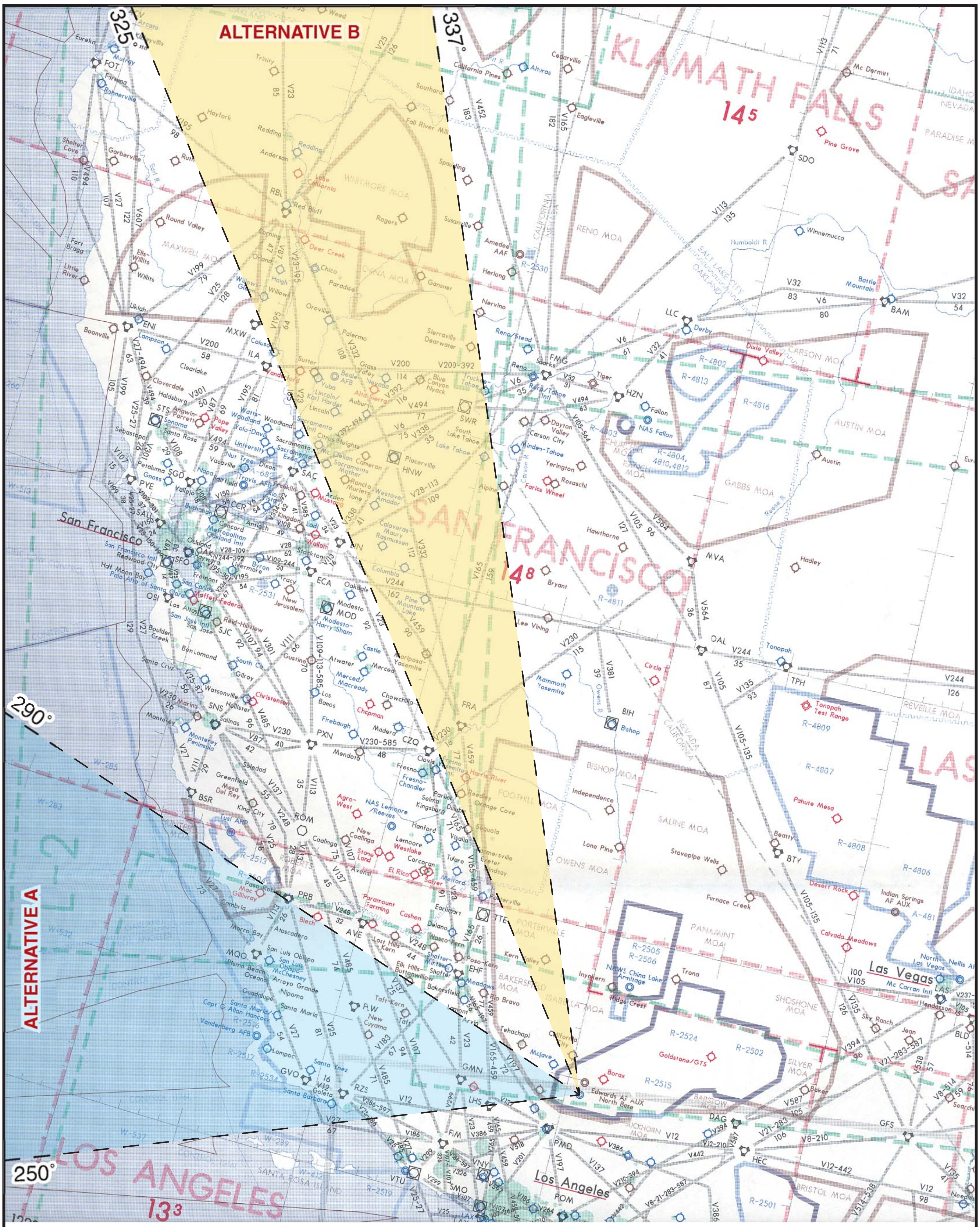
Special use airspace consists of airspace wherein activities must be confined because of their nature, or wherein limitations are imposed upon aircraft operations that are not a part of those activities, or both (FAA 2000a). Special use airspace is depicted on aeronautical charts, except for controlled firing areas. Special use airspace within Alternative A is shown in Figure 3-3. Table 3-6 gives the name/number, effective altitude, time of use, and the controlling agency for the special use airspace within Alternative A.

There are 20,000 square miles of airspace that have been designated as restricted for use by DoD, NASA, and other government agencies. This airspace is over an area 140 miles north to south (Bishop to Edwards AFB) and 110 miles east to west (Nevada state line to Bakersfield). Known by its FAA designation as the R-2508 Complex, this airspace is scheduled, monitored, regulated, and controlled to provide safe aircraft test areas. Aircraft operation characteristics and altitudes are regulated in this airspace to minimize ground-based conflicts, which are primarily due to noise. The R-2508 complex encompasses large portions of Inyo, Kern, San Bernardino, and Tulare counties in east central California. It also includes a portion of Fresno and Los Angeles counties in California and extends into Nevada's Esmeralda County (NASA/Dryden Flight Research Center 1999). The southwestern-most part of the R-2508 Complex lies beneath the Alternative A corridor.

Activities within restricted areas must be confined because of their nature, or due to limitations imposed upon aircraft operations that are not a part of those activities, or both (FAA 2000a). Restricted areas denote the existence of unusual and often invisible hazards to aircraft (FAA 2000a). In addition to the southwestern-most part of the R-2508 Complex, other special use airspace within Alternative A includes the restricted areas R-2516, R-2517, and R-2534 A and B over Vandenberg AFB, and R-2513 and R-2504 complex south of Big Sur along the California coast.

Military Operation Areas (MOAs) are airspace of defined vertical and lateral limits that have been established in order to separate certain military activities from IFR traffic (FAA 2000a). The R-2513/R-2504 complex is surrounded by the Hunter Low A, B, C, D, and E MOAs and the Roberts MOA.

Warning areas are airspace that is of defined dimensions, extending from 3 nautical miles outward from the coast of the United States (FAA 2000a). Warning areas contain activity that may be hazardous to nonparticipating aircraft, and the purpose of warning areas is to warn nonparticipating pilots of the potential danger (FAA 2000a). Further offshore are Warning Areas W-285A, the southern tip of W-285B, W-532, and W-537 (Figure 3-3). There are no prohibited or alert special use airspace areas within Alternative A (National Ocean Service 2000).


ALTERNATIVE B
325°
337°
290°
250°
ALTERNATIVE A
KLAMATH FALLS
14⁵
SAN FRANCISCO
14⁸
LOS ANGELES
13³
Las Vegas
Edwards AF AUX North Base
RENO MOA
GABBS MOA
AUSTIN MOA
CARSON MOA
BISHOP MOA
SALINE MOA
OWENS MOA
PANAMINT MOA
SHOSHONE MOA
SILVER MOA
BAKERSFIELD MOA
ISABELLA MOA
PORTERVILLE MOA
FOOTHILL MOA
WHITMORE MOA
MAXWELL MOA
CHINA MOA
REVEILLE MOA
BRISTOL MOA
BARSTOW MOA
BUCKHORN MOA
R-2505
R-2506
R-2524
R-2502
R-2515
R-4807
R-4808
R-4809
R-4806
R-4811
R-4816
R-4813
R-4802
R-2530
R-2531
R-2513
R-2516
R-2517
R-2534
R-2519
R-2501
W-285
W-283
W-532
W-537
W-289
W-513
W-412
L-2

LEGEND

🟦 Alternative A

🟨 Alternative B

◇○ Civilian Airport

◎ Military Airfield

▥ Special Use Airspace and Warning Areas

— MOA (Military Operation Area)

— Low Altitude Jet Route

0 30 60 90
SCALE IN NAUTICAL MILES

EA for the Orbital Reentry Corridor for Generic Unmanned Lifting Entry Vehicle Landing at Edwards AFB

SPECIAL USE AIRSPACE, WARNING AREAS, LOW ALTITUDE JET ROUTES AND AIRPORTS UNDER ALTERNATIVE A AND ALTERNATIVE B

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TASK NO.	DATE	DRAWN BY	FILE NO.	FIGURE NO.
Q202-0701	11/6/02	IGE	Graphics:\Edwards AFB\ Re-Entry Corridor EA Task 2\3-3LowAlt AB.ai	3-3

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Table 3-6
Special Use Airspace Within Alternative A (Western Approach)

Number/Name	Effective Altitude (feet)	Time of Use	Controlling Agency
R-2504	To 15,000	0600–2400 PST	ZOA CNTR
R-2513	To FL 240	Continuous	ZOA CNTR
R-2516	Unlimited	Continuous	ZLA CNTR
R-2517	Unlimited	Continuous	No A/G
R-2534A	500 AGL to Unlimited	Intermittent by NOTAM	ZLA CNTR
R-2534B	500 AGL to Unlimited	Intermittent by NOTAM	ZLA CNTR
Hunter Low A MOA	200 AGL to 11,000	Intermittent by NOTAM	ZOA CNTR
Hunter Low B MOA	2,000 AGL to 11,000	Intermittent by NOTAM	ZOA CNTR
Hunter Low C MOA	3,000 AGL to 11,000	Intermittent by NOTAM	ZOA CNTR
Hunter Low D MOA	1,500 AGL to 6,000	Intermittent by NOTAM	ZOA CNTR
Hunter Low E MOA	1,500 AGL to 3,000	Intermittent by NOTAM	ZOA CNTR
Hunter High MOA	11,000 to FL 180	Intermittent by NOTAM	ZOA CNTR
Roberts MOA	500 to 15,000	Intermittent by NOTAM	ZOA CNTR
W-285A	To FL 450	0500–2100 M–F	ZOA CNTR
W-285B	To FL 450	0500–2100 M–F	ZOA CNTR
W-532	Unlimited	Intermittent	ZLA CNTR
W-537	Unlimited	Intermittent	ZLA CNTR
R-2508 Complex			
R-2508	FL 200 to Unlimited	Continuous	HI-DESERT TRACON
R-2515	Unlimited	Continuous	HI-DESERT TRACON
Bakersfield MOA	2,000 AGL[2]	0600–2200 M-F	ZLA CNTR
Isabella MOA	200 AGL[2,3]	0600–2200 M-F	HI-DESERT TRACON

Notes: 1-Not including the indicated altitude.
2- Up to but not including FL 180.
3- Excluding 3,000 and below over Domeland Wilderness Area.
AGL- above ground level
ARTCC- Air Route Traffic Control Center
CNTR- Center (ARTCC)
FL- flight level (FL 180 = approximately 18,000 feet above mean sea level)
MOA- Military Operation Area
NOTAM- Notice to Airmen
R- restricted
TRACON- Terminal Radar Control
ZLA- Los Angeles ARTCC
ZOA- Oakland ARTCC

Sources: National Aeronautical Charting Office 2001b, 2001c.

3.2.1.3 Military Training Routes

Alternative A contains several IFR and VFR low altitude military training routes and one slow-speed, low-altitude training route (SR-390) (Figure 3-4). Colored routes/low-level supersonic/terrain following routes are military training routes used primarily by Edwards AFB and are controlled by AFFTC through the High Desert Terminal Radar Approach Control (TRACON). All routes within the ROI are within the boundaries of the R-2508 Complex, and are governed by the flight restrictions and requirements to "see and avoid" other aircraft when operating under VFR. All routes are designated as "military assumes responsibility for separation of aircraft" (MARSA) operations, which are established by coordinated scheduling. Hours of operation are normally daylight hours. Other hours are by Notice to Airmen (NOTAM), except for IR 211 and VRs 1206 and 1265, which have continuous hours of operation (National Imagery and Mapping Agency 2001).

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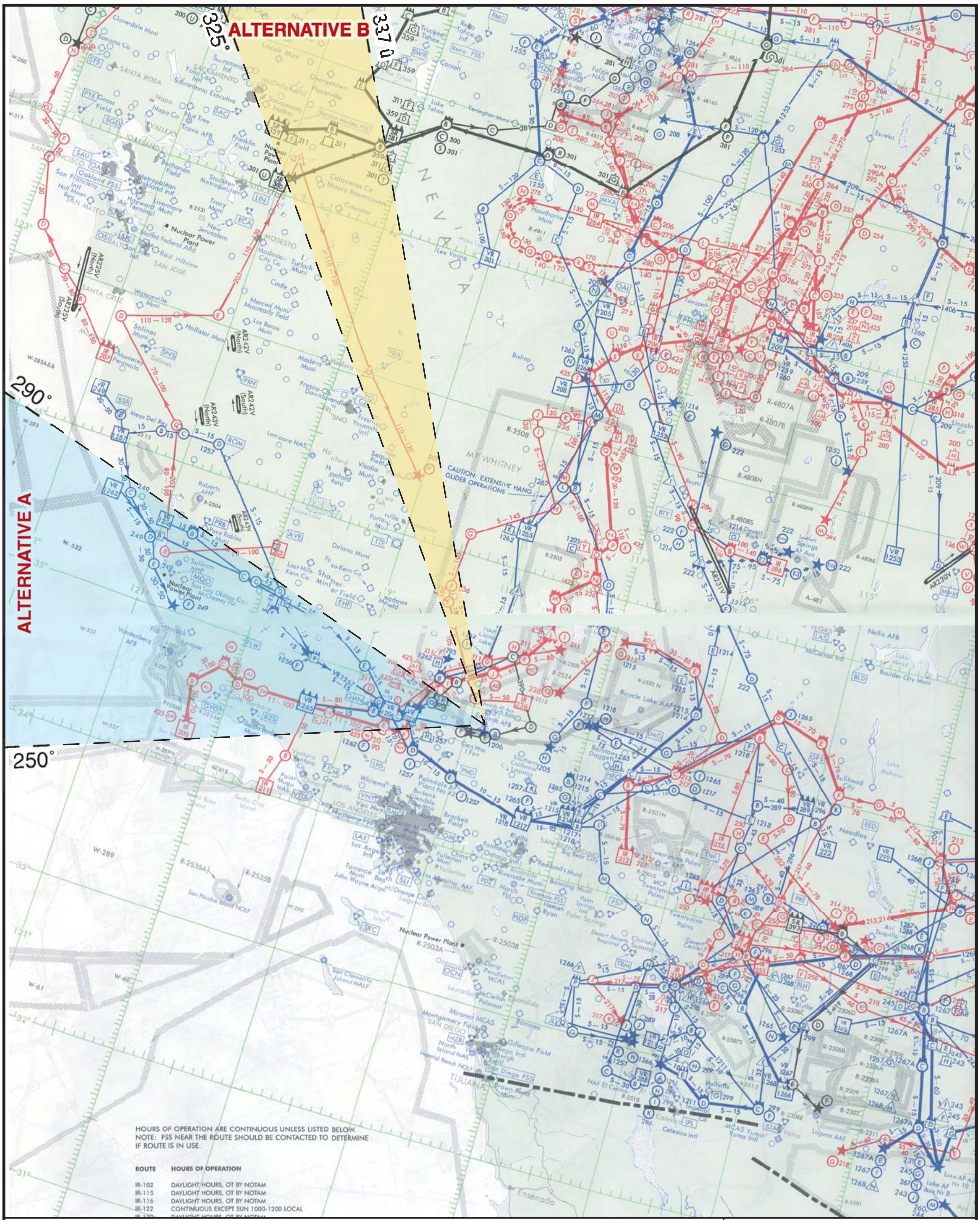
ALTERNATIVE B
325°
337°
ALTERNATIVE A
290°
250°
NEVADA
HOURS OF OPERATION ARE CONTINUOUS UNLESS LISTED BELOW.
NOTE: FSS NEAR THE ROUTE SHOULD BE CONTACTED TO DETERMINE IF ROUTE IS IN USE.
ROUTE HOURS OF OPERATION
IR-102 DAYLIGHT HOURS, OT BY NOTAM
IR-115 DAYLIGHT HOURS, OT BY NOTAM
IR-116 DAYLIGHT HOURS, OT BY NOTAM
IR-122 CONTINUOUS EXCEPT SUN 1000-1200 LOCAL

LEGEND

▭	Alternative A
▭	Alternative B
▨	Special Use Air Space and Warning Areas
◇○	Civilian Airport
◎	Military Airfields
—	Instrument Route (IR) Military Training Route
—	Visual Route (VR) Military Training Route
—	Slow Route (SR) Military Training Route

N

0 30 60 90
SCALE IN NAUTICAL MILES

EA for the Orbital Reentry Corridor for
Unmanned Lifting Entry Vehicle Landing
at Edwards AFB, CA

MILITARY TRAINING ROUTES
UNDER ALTERNATIVES A AND B

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TASK NO.	DATE	DRAWN BY	FILE NO.	FIGURE NO.
Q202-0501	2/22/02	RANDALL	Graphics:\Edwards AFB\ Re-Entry Corridor EA Task 2\3-7 MTRs B.ai	3-4

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All LEV flights profiles within Alternative A maintain a vertical separation of over 60,000 feet from all aircraft that could be using the IFR and VFR military training routes until the LEV is inside the boundaries of the R-2508 Complex.

3.2.1.4 En Route Airways and Jet Routes

There are a total of 14 en route low altitude (up to but not including 18,000 feet above msl) airways that transect the airspace within Alternative A (Figure 3-3).

Several high-altitude jet routes cross below the horizontal boundaries of Alternative A (Figure 3-5). From east to west, these are the J6-65, J50, J5, J5-50-65, J6, J1, J7, J1-7, J88-126, and J501 jet routes, all overland. Offshore, high-altitude jet routes cross through Warning Area W-532 utilizing one control area extension (CAE) corridor, Control 1155, and through Warning Area W-537 utilizing CAE 1176 (Figure 3-5). This CAE corridor can be opened or closed at the request of a user in coordination with the FAA. Memoranda of Agreement exist between users and the FAA that stipulate the conditions under which CAEs can be closed to civil traffic. Under most circumstances at least one of the numerous CAE corridors off the California coast must remain available for use by general aviation and commercial air carriers.

Most commercial air traffic flies below 43,000 feet, although some private jets reach altitudes of 50,000 feet. In addition to the IFR high altitude jet routes and low altitude airways used by commercial aircraft, general aviation aircraft fly unrestricted in accordance with VFR within the Alternative A airspace.

As an alternative to aircraft flying above 29,000 feet following the published, preferred IFR routes (shown in Figure 3-5), the FAA is gradually permitting pilots to select their own routes. This “Free Flight” program is an innovative concept designed to enhance the safety and efficiency of the NAS. The concept moves the NAS from a centralized command-and-control system between pilots and air traffic controllers to a distributed system that allows pilots, whenever practical, to choose their own route and file a flight plan that follows the most efficient and economical route (FAA 1998).

Free Flight is already underway, and the plan for full implementation will occur as procedures are modified and technologies become available and are acquired by users and service providers. This incremental approach balances the needs of the aviation community and the expected resources of both the FAA and the users. Advanced satellite voice and data communications are being used to provide faster and more reliable transmission to enable reductions in vertical, lateral, and longitudinal separation, more direct flights and tracks, and faster altitude clearances (FAA 1998). With the full implementation of this program, the amount of airspace within the ROI likely to be clear of traffic will decrease as pilots file a flight plan that follows the most efficient and economical route, rather than following the published preferred IFR routes across the ROI.

3.2.1.5 Airports/Airfields

There are a number of airports within the Alternative A corridor, including, from east to west, Rosamond, Taft-Kern County, Santa Barbara, Santa Ynez, Lompoc, Santa Maria, San Luis Obispo, and Oceano County Airports. In addition, numerous private airports/airstrips and Vandenberg AFB lie within the Alternative A corridor. Paso Robles Airport lies just outside the corridor to its north (Figures 3-3 and 3-6).

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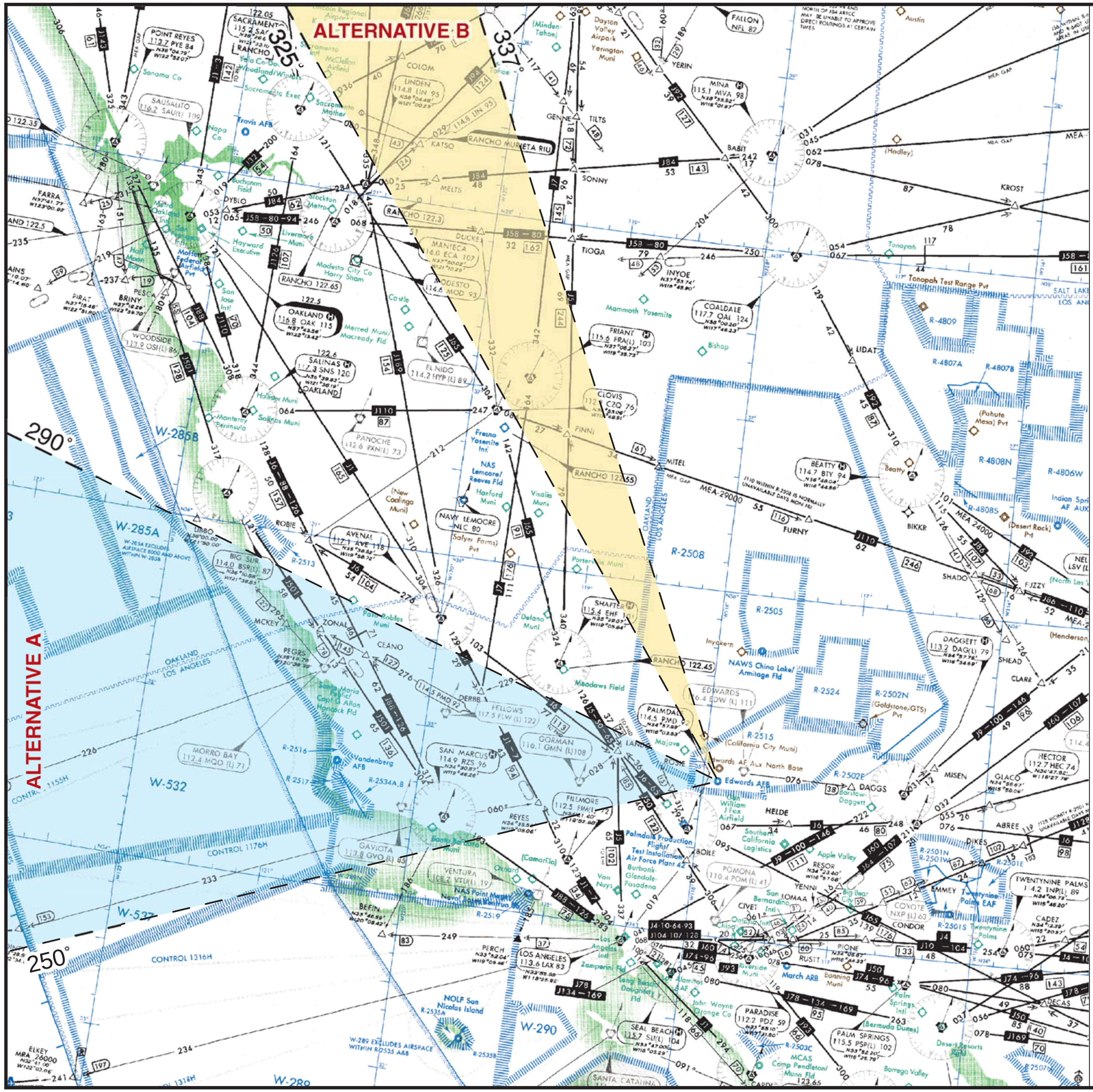
ALTERNATIVE B
ALTERNATIVE A
325°
337°
290°
250°
W-285A
W-285B
W-532
W-537
W-289
W-290
R-2508
R-2505
R-2524
R-2502N
R-2515
Edwards AFB
CONTROL 1176H
CONTROL 1316H

LEGEND

▭	Alternative A
▭	Alternative B
J92	High Altitude Jet Routes
▥	Special Use Airspace and Warning Areas
◇ ○	Civilian Airport
◎	Military Airfield

N

0 20 40 60

SCALE IN NAUTICAL MILES

EA for the Orbital Reentry Corridor for Generic Unmanned Lifting Entry Vehicle Landing at Edwards AFB

HIGH ALTITUDE JET ROUTES UNDER ALTERNATIVES A AND B

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TASK NO.	DATE	DRAWN BY	FILE NO.	FIGURE NO.
Q202-0701	11/6/02	IGE	Graphics:\Edwards AFB\ Re-Entry Corridor EA Task 2\3-5HiAlt AB.ai	3-5

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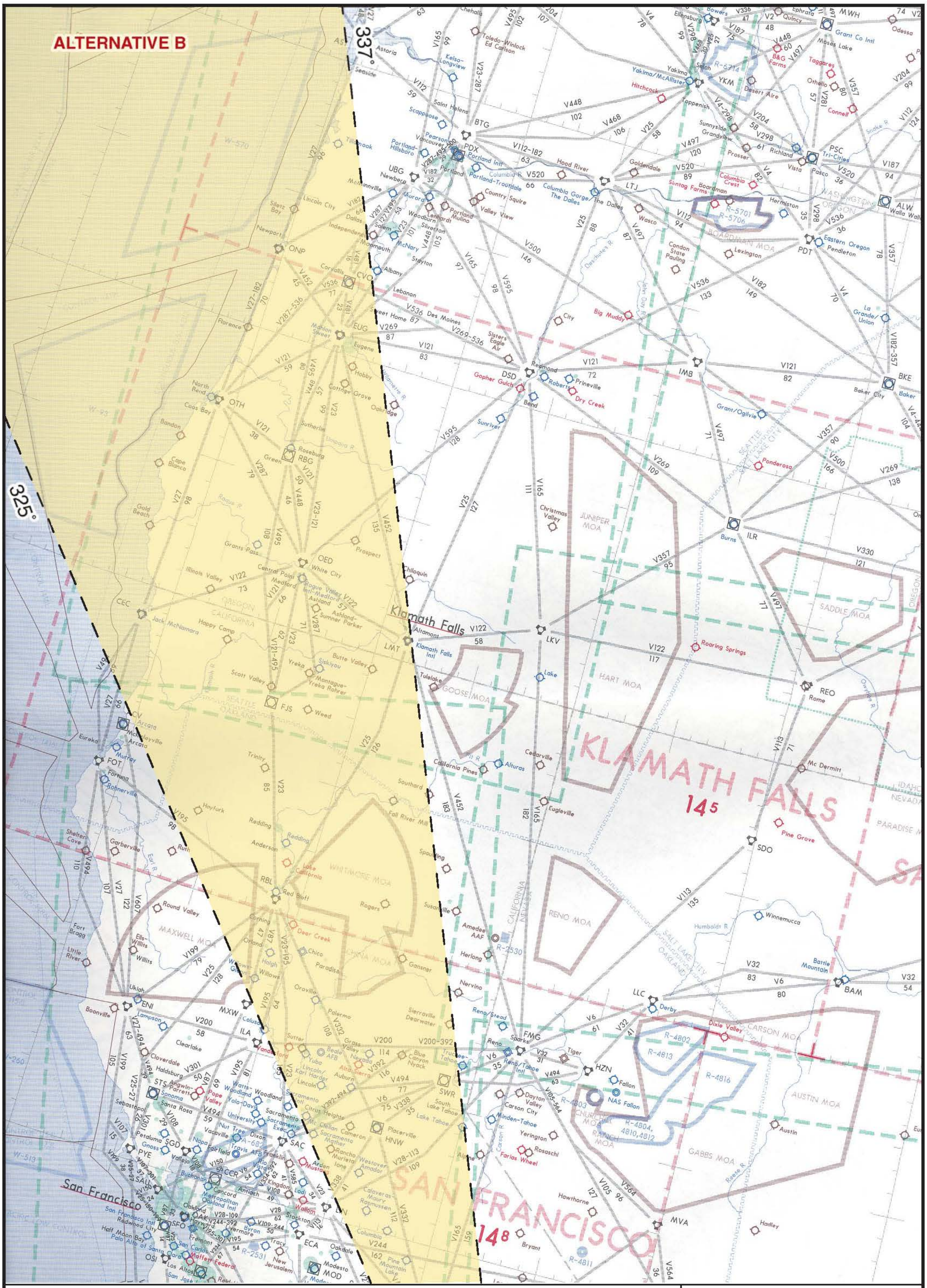
ALTERNATIVE B
337°
325°
KLAMATH FALLS
145
SAN FRANCISCO
148
Klamath Falls
San Francisco
HART MOA
JUNIPER MOA
SADDLE MOA
GOOSE MOA
WHITMORE MOA
MAXWELL MOA
RENO MOA
CARSON MOA
AUSTIN MOA
GABBS MOA
BOARDMAN MOA
PARADISE MOA
R-4803
R-4804, 4810,4812
R-4813
R-4816
R-5701
R-5706
W-570
W-513
PDX
EUG
OTH
RBG
LMT
FJS
RBL
SAC
SFO
OAK
LKV
REO
HZN
FMG
MVA
BAM
BKE
PDT
DSD
IMB
ILR
SDO
YKM

LEGEND

▭ Alternative A

▭ Alternative B

▨ Special Use Airspace and Warning Areas

— Low Altitude Jet Route

○ Civilian Airport

◎ Military Airfield

▬ MOA (Military Operation Area)

N

0 30 60 90

SCALE IN NAUTICAL MILES

SPECIAL USE AIRSPACE, WARNING AREAS, LOW ALTITUDE JET ROUTES AND AIRPORTS UNDER ALTERNATIVE B

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TASK NO.	DATE	DRAWN BY	FILE NO.	FIGURE NO.
Q202-0701	11/6/02	IGE	Graphics:\Edwards AFB\ Re-Entry Corridor EA Task 2\3-4 LowAlt B.ai	3-6

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3.2.1.6 Air Traffic Control

Alternative A lies principally within the Los Angeles Air Route Traffic Control Center's (ARTCC's) boundaries, with the exception of the far northwestern part of the ROI north of Morro Bay, which is within the Oakland ARTCC (National Aeronautical Charting Office [NACO] 2001c). The controlling agency for the Restricted Areas and MOAs within the R-2508 Complex is TRACON. The other controlling agencies for the Restricted Areas and MOAs within Alternative A are the Los Angeles and Oakland ARTCCs. During the published hours of use (identified in Table 3-6), the using agency is responsible for controlling all military activity within the special use airspace and ensuring that its perimeters are not violated. When scheduled to be inactive the using agency releases the airspace back to the controlling agency (Los Angeles or Oakland ARTCCs), and in effect, the airspace is no longer restricted. If no activity is scheduled during some of the published hours of use, the using agency releases the airspace to the controlling agency for non-military operations for that period of inactivity (Illman 1993).

In the Class A (positive control area) airspace from 5,486 to 18,288 meters (18,000 to 60,000 feet) within Alternative A, all operations are conducted under IFR procedures and are subject to ATC clearances and instructions. Aircraft separation and safety advisories are provided by ATC, or by the Los Angeles or Oakland ARTCCs. In the Class E airspace (general controlled airspace) below 5,486 meters (18,000 feet) operations may be under either IFR or VFR. The Los Angeles or Oakland ARTCCs provide separation service to aircraft operating under IFR only, and to the extent practicable, provide traffic advisories to aircraft operating under VFR.

Today, the NAS has no defined upper limit. However, by 2005 the NAS may have a defined (but currently unspecified) upper limit in order to clearly define the FAA's responsibility for accommodating vehicles transitioning to and from space.

3.2.2 Alternative B (Northwestern Approach)

3.2.2.1 Controlled and Uncontrolled Airspace

Other than the special use airspace identified below (see Section 3.2.2.2), all airspace within Alternative B and within 750 nautical miles of Edwards AFB is Class A, Class C, Class D, or Class E controlled airspace, within which some or all aircraft may be subject to ATC. Within the Class E airspace, separation service is provided for IFR aircraft only, and to the extent practical, traffic advisories are provided for aircraft operating under VFR. The Class E airspace has a floor of 1,200 feet or greater above the surface, except for the areas around the numerous airports within Alternative B, where the Class E airspace has a floor of 700 feet above the surface. There is no Class B airspace within Alternative B. All airspace above FL 600 is uncontrolled (Class E) airspace.

3.2.2.2 Special Use Airspace

Within Alternative B is the western portion of the R-2508 Complex, which consists of the R-2515 and R-2508 Restricted Areas and the Isabella, Bakersfield, and Porterville MOAs (Figures 3-3 and 3-6). Other special use airspace under the entry corridor outside the R-2508 Complex includes the Foothill 1 and 2, Maxwell 1 and 4, China, and Whitmore 1, 2, and 3 MOAs southwest and northeast of Red Bluff, California. Offshore are the W-93 and W-570 Warning Areas off Oregon, and the W-237 Warning Area complex off Washington. Table 3-7 gives the name/number, effective altitude, time of use, and the controlling agency for the special use airspace within Alternative B.

Table 3-7
Special Use Airspace within Alternative B (Northwestern Approach)

Number/Name	Effective Altitude (feet)	Time of Use	Controlling Agency
R-2508	FL200-Unlimited	Continuous	HI-DESERT TRACON
R-2515	Unlimited	Continuous	HI-DESERT TRACON
Bakersfield MOA	2,000 AGL[1]	0600–2200 M–F	ZLA CNTR
China MOA	3,000 AGL[1]	1600–Sunset	ZOA CNTR
Foothill 1 MOA	2,000 AGL[1]	Intermittent By NOTAM	ZOA CNTR
Foothill 2 MOA	2,000 AGL[1]	Intermittent By NOTAM	ZOA CNTR
Isabella MOA	200 AGL[1,2]	0600–2200 M–F	HI-DESERT TRACON
Maxwell 1 MOA	11,000 or 3,000 AGL[3]	1300–0400 M–F	ZOA CNTR
Maxwell 2 MOA	11,000 or 3,000 AGL[3]	1300–0400 M–F	ZOA CNTR
Porterville MOA	200 AGL[1]	0600–2200 M–F	ZLA CNTR
Whitmore 1 MOA	11,000 or 3,000 AGL[3]	1530–0030 M–F	ZOA CNTR
Whitmore 2 MOA	11,000 or 3,000 AGL[3]	1530–0030 M–F	ZOA CNTR
Whitmore 3 MOA	11,000 or 3,000 AGL[3]	1530–0030 M–F	ZOA CNTR
W-93	To FL 500	By NOTAM	ZSE CNTR
W-237A & B Low	FL 230[4]	By NOTAM	ZSE CNTR
W-237C & D	Unlimited	By NOTAM	ZSE CNTR
W-237E	To FL 270	By NOTAM	ZSE CNTR
W-570	To FL 500	By NOTAM	ZSE CNTR

Notes: 1 - Up to but not including FL180.
2 - Excluding 3,000 and below over Domeland Wilderness Area.
3 - Whichever is greater.
4 - Up to but not including indicated altitude.
AGL - above ground level
ARTCC - Air Route Traffic Control Center
CNTR - Center (ARTCC)
FL - flight level (FL 180 = approximately 18,000 feet)
MOA - Military Operation Area
R - Restricted
ZLA - Los Angeles ARTCC
ZOA - Oakland ARTCC
ZSE - Seattle ARTCC

Sources: NACO 2001b, 2001c.

3.2.2.3 Military Training Routes

The Alternative B airspace contains several IFR and VFR low altitude military training routes including colored routes/low-level supersonic/terrain following routes, and several slow speed, low altitude training routes (SR-300, SR-301, SR-311, SR-353, and SR-359) (Figures 3-4 and 3-7). All routes within the ROI are within the boundaries of the R-2508 Complex, and are governed by the flight restrictions and requirements to "see and avoid" other aircraft when operating under VFR. All routes are designated as MARSA operations, which are established by coordinated scheduling. Hours of operation are normally daylight hours. Other hours are by NOTAM, except for VR-1206, VR-1293, IR-211, IR-346, SR-300, and SR-311, which have continuous hours of operation (National Imagery and Mapping Agency 2001).

All LEV flight profiles within Alternative B would maintain a vertical separation of over 60,000 feet from all aircraft that could be using the IFR and VFR military training routes until the LEV is inside the boundaries of the R-2508 Complex.

3.2.2.4 En Route Airways and Jet Routes

There are a total of 28 low altitude (up to but not including 18,000 feet above msl) airways that transect the airspace within Alternative B (Figures 3-3 and 3-6).

Alternative B also contains 19 high altitude jet routes above 18,000 feet above msl that cross below the horizontal boundaries of the corridor. From north to south these are J501, J136, J589, J143, J126, J1, J1-126, J65, J189, J3, J67, J65-126, J32, J94, J84, J58-80, J7, J5, and J110 (Figures 3-5 and 3-8). The J110 jet route, which transects the R-2508 Complex from east to west, is normally unavailable within the R-2508 Complex during the week. Most commercial air traffic flies below 43,000 feet, although some private jets reach altitudes of 50,000 feet. In addition to the IFR high altitude jet routes and low altitude airways used by commercial aircraft, general aviation aircraft fly unrestricted in accordance with VFR within Alternative B.

The Free Flight program described under Alternative A is also beginning in the Alternative B corridor. With the full implementation of this program, the amount of airspace within the ROI likely to be clear of traffic will decrease as pilots file a flight plan that follows the most efficient and economical route, rather than following the published preferred IFR routes across the ROI.

3.2.2.5 Airports/Airfields

There are a number of airports within Alternative B including, from south to north, California City, Kern Valley, Harris River, Mariposa-Yosemite, Pine Mountain Lake, Columbia, Calaveras-Maury Rasmussen, Westover Amador, Rancho Murieta Sacramento Mather, McCellan, Cameron, Lake Tahoe, Lincoln Karl Harder, Alta Sierra, Yuba County, Georgetown, Placerville, Beale AFB, Sutter, Auburn, Nevada, Blue Canyon Nyack, Sierra Dearwater, Oroville, Gansner, Chico, Willow-Glenn, Haigh, Deer Creek, Rogers, Lake California, Redding Muni, Fall River Mill, Hayfork, Trinity, Weed, Siskikyou Co., Scott Valley, Butte Valley, Happy Camp, Jack McNamara Field, Illinois Valley, Ashland Muni-Summer Parker Field, Rogue Valley International-Medford, Grants Pass, Prospect, Gold Beach Muni, Cape Blanco State, Rosenburg Regional, North Bend Muni, Cottage Grove, Hobby Field, Florence Muni, Mahlon Sweet, Corvalis Muni, Newport Muni, Siletz State, Lincoln City, and Tillamook Airports, along with numerous private airfields and airstrips (Figures 3-3 and 3-6). None of these are major commercial airports. However, there are two Air Force bases, McClellan AFB and Beal AFB, located just north of Sacramento, California.

3.2.2.6 Air Traffic Control

Alternative B airspace lies principally within the Los Angeles, Oakland, and Seattle ARTCC's boundaries (NACO 2001c). The controlling agencies for the Restricted Areas, MOAs, and associated ATCAAs are identified in Table 3-7. During the published hours of use (also identified in Table 3-7), the using agency is responsible for controlling all military activity within the special use airspace and ensuring that its perimeters are not violated. When scheduled to be inactive, the using agency releases the airspace back to the controlling agency and, in effect, the airspace is no longer restricted. If no activity is scheduled during some of the published hours of use, the using agency releases the airspace to the controlling agency for non-military operations for that period of inactivity (Illman 1993).

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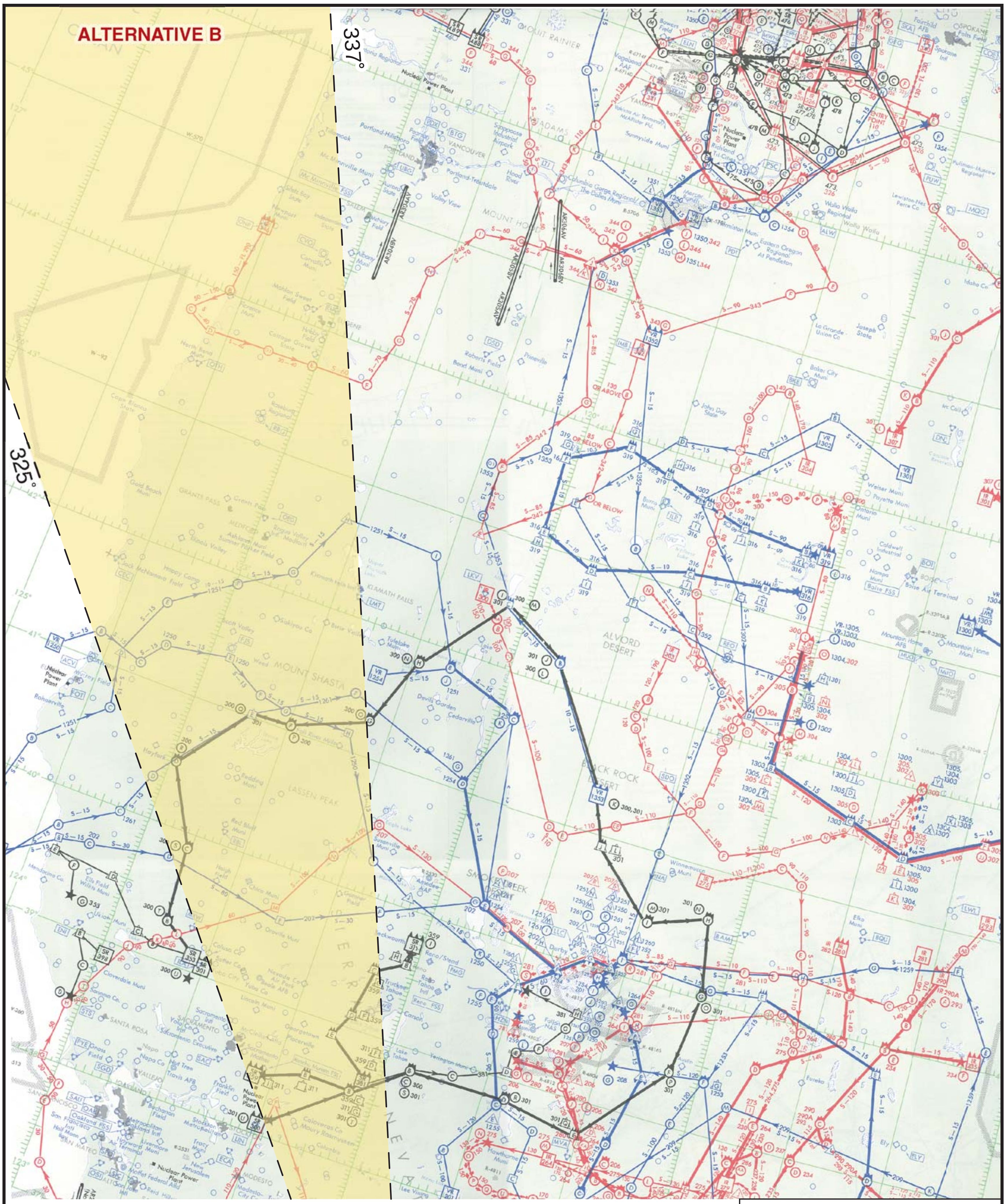
ALTERNATIVE B
337°
325°
MOUNT SHASTA
ALVORD DESERT
LASSEN PEAK
VANCOUVER
SANTA ROSA
SACRAMENTO

LEGEND

▨ Alternative B

J92 Jet Routes

▨ Special Use Air Space and Warning Areas

◇○ Civilian Airport

◎ Military Airfields

Instrument Route (IR) Military Training Route

Visual Route (VR) Military Training Route

Slow Route (SR) Military Training Route

0 30 60 90
SCALE IN NAUTICAL MILES

EA for the Orbital Reentry Corridor for Generic Lifting Vehicle Landing at Edwards AFB

MILITARY TRAINING ROUTES
UNDER ALTERNATIVE B

Tetra Tech, Inc.
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Santa Barbara, CA 93110-2847

TASK NO.	DATE	DRAWN BY	FILE NO.	FIGURE NO.
Q202-0501	2/21/02	IGE	Graphics:\Edwards AFB\ Re-EntryCorridorEA Task 2\3-8 MTRs B.ai	3-7

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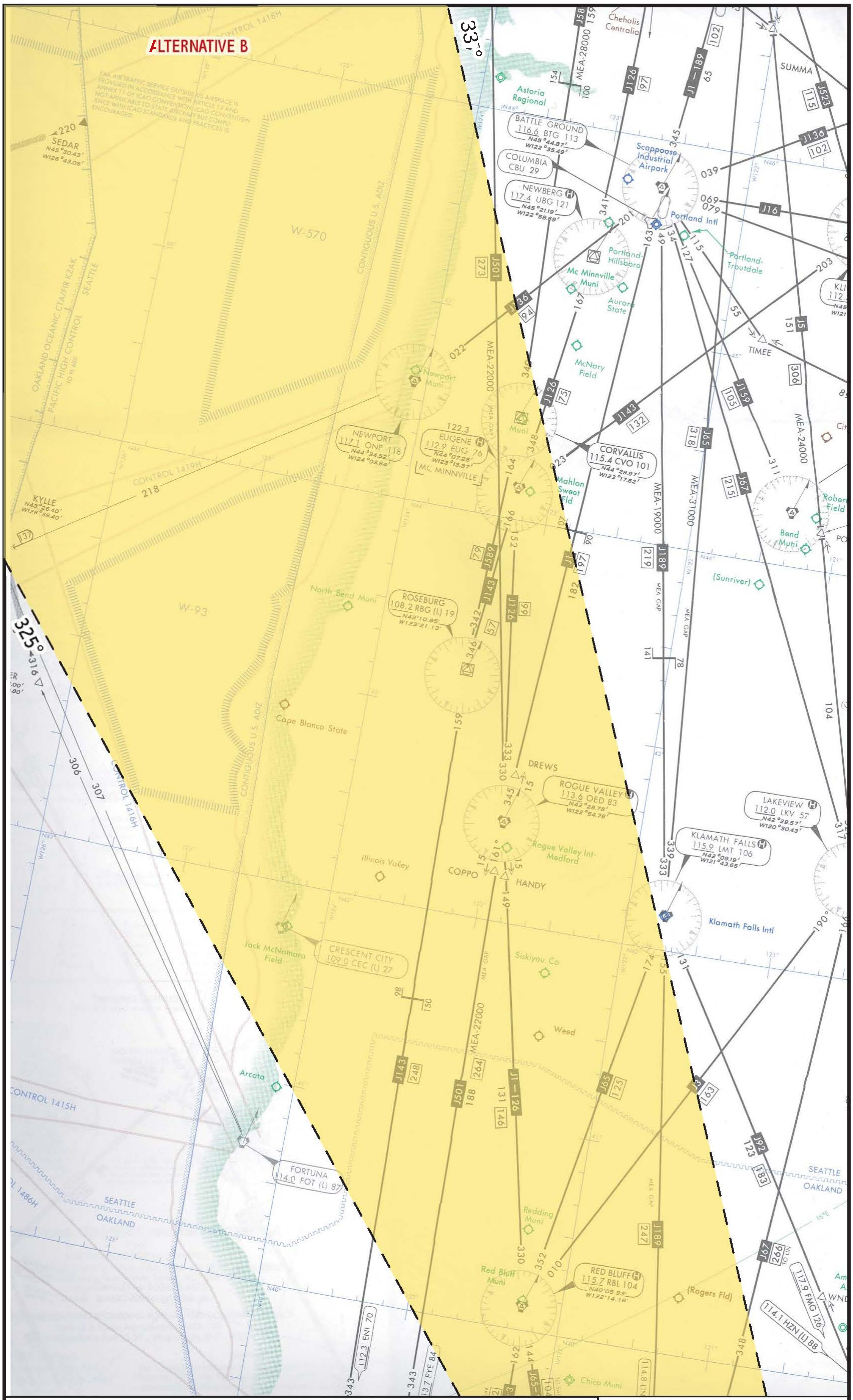
ALTERNATIVE B
337°
325°
W-570
W-93
CONTIGUOUS U.S. ADIZ
OAKLAND OCEANIC CTA/FIR KZAK
PACIFIC HIGH CONTROL
SEATTLE
CONTROL 1418H
CONTROL 1419H
CONTROL 1416H
CONTROL 1415H
SEDAR
KYLLE
Chehalis Centralia
Astoria Regional
BATTLE GROUND 116.6 BTG 113
COLUMBIA CBU 29
NEWBERG 117.4 UBG 121
Scappoose Industrial Airpark
Portland Intl
Portland-Hillsboro
Portland-Troutdale
Mc Minnville Muni
Aurora State
McNary Field
SUMMA
TIMEE
Newport Muni
NEWPORT 117.1 ONP 116
EUGENE 112.9 EUG 76
MC MINNVILLE
CORVALLIS 115.4 CVO 101
Mahlon Sweet Fld
North Bend Muni
ROSEBURG 108.2 RBG (L) 19
Bend Muni
(Sunriver)
Cape Blanco State
DREWS
ROGUE VALLEY 113.6 OED 83
Rogue Valley Intl-Medford
Illinois Valley
COPPO
HANDY
LAKEVIEW 112.0 LKV 57
KLAMATH FALLS 115.9 LMT 106
Klamath Falls Intl
Jack McNamara Field
CRESCENT CITY 109.0 CEC (L) 27
Siskiyou Co
Weed
Arcata
FORTUNA 114.0 FOT (L) 87
SEATTLE OAKLAND
Redding Muni
Red Bluff Muni
RED BLUFF 115.7 RBL 104
(Rogers Fld)
Chico Muni
J501
J143
J126
J189
J5
J65
J67
J1-126
J159
J16
J136
J92
J589
MEA-22000
MEA-19000
MEA-31000
MEA-24000
MEA-28000

LEGEND

▭ Alternative

J92 High Altitude Jet Routes

◇○ Civilian Airport

◎ Military Airfield

▥ Special Use Air Space and Warning Areas

0 30 60 120

SCALE IN NAUTICAL MILES

EA for the Orbital Reentry Corridor for Generic Unmanned Lifting Entry Vehicle Landing at Edwards AFB

HIGH ALTITUDE JET ROUTES UNDER ALTERNATIVE B

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TASK NO.	DAT	DRAWN BY	AI FILE NO.	FIGURE NO.
Q202-0701	11/6/02	RANDALL	Graphics: \Edwards AFB\ Re-Entry Corridor EA Task 2\3-6 HiAlt B.ai	3-8

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In Class A (positive control area) airspace within Alternative B, all operations are conducted under IFR procedures and are subject to ATC clearances and instructions. Aircraft separation and safety advisories are provided by ATC at the appropriate ARTCC. In Class E airspace below 5,486 meters (18,000 feet), operations may be either under IFR or VFR. Each ARTCC provides separation service to aircraft operating under IFR only, and to the extent practicable, traffic advisories are provided for aircraft operating under VFR.

Today, the NAS has no defined upper limit. However, by 2005 the NAS may have a defined (but currently unspecified) upper limit in order to clearly define the FAA's responsibility for accommodating vehicles transitioning to and from space.

3.3 CULTURAL RESOURCES

Cultural resources are those aspects of the physical environment that relate to human culture and society, and those cultural institutions that hold communities together and link them to their surroundings. Cultural resources include expressions of human culture and history in the physical environment such as prehistoric or historic archaeological sites, buildings, structures, objects, districts, or other places including natural features and biota that are considered to be important to a culture, subculture, or community. Cultural resources also include traditional lifeways and practices, and community values and institutions.

For this EA, cultural resources have been organized into the categories of prehistoric resources, historic resources, and traditional cultural properties (TCPs) and practices. These types are not exclusive and a single cultural resource may have multiple components.

Prehistoric cultural resources refer to any material remains, structures and items used or modified by people before the establishment of a Euro-American presence in the region. For this part of California, the first direct contact with Euro-Americans was earlier on the coast and Channel Islands and later in inland areas. The earliest brief encounters by explorers began in the mid-sixteenth century followed by colonization and settlement by the late eighteenth century. Examples of prehistoric cultural resources recorded in the region include the archaeological remains of villages, camps, quarries, rock shelters, rock art, milling features, cemeteries and scatters of prehistoric artifacts, such as pottery sherds, shell remains, or stone tool-making debris.

Historic cultural resources include the material remains and landscape alterations that have occurred since the arrival of Euro-Americans in the region. Examples of historic cultural resources in the region include homestead and agricultural features, foundations, roads, buildings, water conveyance and control features, scatters of historic artifacts, post–contact Native American villages, and locations or structures that are associated with the historic events or people.

Traditional cultural properties and practices refer to places or activities associated with the cultural heritage or beliefs of a living community and that are important in maintaining cultural identity. Examples of TCPs may include natural landscape features; places used for ceremonies and worship; ancestral villages or burial sites; places where plants are gathered that are used in traditional medicines and ceremonies; places where artisan materials are found; places where traditional arts are practiced or passed on; and features of traditional subsistence systems. Impacts to the maintenance of TCPs are also considered in NEPA analyses.

3.3.1 On-Base Region

Edwards AFB has the most comprehensive cultural resource identification program in the vicinity of the corridors. To date, approximately 435 archaeological surveys covering a total of 66,502 acres have been completed on base. As a result of this work, 1,084 prehistoric sites, 1,085 historic sites, and 1 National Landmark have been recorded on base (Ronning *et al*. 2000).

One hundred twenty-six prehistoric sites on Edwards AFB have been tested. The evaluators found 28 of these sites individually potentially eligible for the National Register of Historic Places (NRHP) and 18 potentially eligible as contributing elements to historic districts. The evaluators determined that 66 sites are not eligible for the NRHP, and no determination of eligibility was made for 22 sites. The most common prehistoric site types are lithic scatters, temporary camps, hearth features, and milling stations (Earle *et al*. 1997).

Fifty-seven historic archaeological sites on Edwards AFB have been tested. The evaluators found 10 of these sites individually potentially eligible for the NRHP and 11 potentially eligible as contributing elements to historic districts. The evaluators determined 32 sites are not eligible for the NRHP, and no determination of eligibility was made for 3 sites. The most common historic archaeological site types are refuse scatters, homestead sites, mining sites, various agricultural features and inactive military buildings or ruins.

Studies of the built environment on Edwards AFB generally concern military buildings and structures associated with three historic themes: World War II, the Cold War, and Man in Space. Many of the military buildings and structures on Edwards AFB are less than 50 years old and must possess "exceptional significance" to be found eligible for the NRHP. To date three historic districts consisting of 101 contributing elements have been proposed at the X-15 Complex, [Jet Propulsion Laboratory (JPL) Edwards Test Station, and North Base]. In addition, three individual buildings or structures have been proposed as eligible properties.

Rogers Dry Lake is a National Historic Landmark and the primary resource responsible for the establishment of Edwards AFB and the Dryden Flight Research Facility. The lakebed is associated with historic aviation developments including the flight of the Bell X-1, the first plane to break the sound barrier, in 1947, and the first Space Shuttle landing, in 1981 (Earle *et al*. 1998).

3.3.2 Off-Base Region

3.3.2.1 Alternative A (Western Approach)

The proposed reentry corridor for Alternative A passes over large landmasses with a wide variety of physiographic features and environments. The types of cultural resources present likewise reflect the complexities of the human use and modification of these lands during the recent past and throughout at least 10,000 years of human occupation. Hundreds of cultural resources are recorded below the corridors and full inventory of all cultural resources in the reentry corridors has not taken place. Integrity of setting is generally most relevant to the significance of buildings and TCPs rather than archaeological sites.

Only those reservations within a 150-mile radius around Edwards AFB were assumed to be potentially affected by sonic boom noise and visual impacts. Within this radius, Alternative A contains the Santa Ynez Band of Mission Indians Reservation, located in Santa Barbara County, California; the San Manuel Band of Mission Indians Reservation and Chemehueyi Reservation, located within San Bernardino County, California; and the Tule River Reservation, located in Tulare County, California.

3.3.2.2 Alternative B (Northwestern Approach)

The proposed reentry corridor for Alternative B passes over large landmasses with a wide variety of physiographic features and environments. The types of cultural resources present likewise reflect the complexities of the human use and modification of these lands during the recent past and throughout at least 10,000 years of human occupation. Hundreds of cultural resources are recorded below the corridors and full inventory of all cultural resources in the reentry corridors has not taken place. Integrity of setting is generally most relevant to the significance of buildings and TCPs rather than archaeological sites.

Only those reservations within a 150-mile radius around Edwards AFB were assumed to be potentially affected by sonic boom noise and visual impacts. Alternative B contains only the Tule River Reservation, located within Tulare County, California, within this radius.

3.4 ENVIRONMENTAL JUSTICE

Executive Order 12898*, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, requires federal agencies to develop environmental justice strategies and make environmental justice a part of its mission by identifying and addressing disproportionately high adverse effects of its activities on minority and low-income populations.

The alternatives for the Orbital Reentry Corridor Program were identified by using a two-step process. First, a QRA (see Appendix A) was performed for all reentry azimuths between 220 degrees and 020 degrees relative to Edwards AFB extending from the approach end of Runway 22 and encompassing all land, population centers, and aircraft flight routes along each azimuth. This risk analysis weighed the E_c at each point along the ground track and the P_I against the FAA and Air Force standards. Azimuths that had an E_c less than or equal to 30 causalities per million missions and a P_I of less than 1 impact in 10 million missions were identified for further consideration. Next, the Air Force selected the corridors for Alternatives A and B for assessment under this EA based on the most probable orbital reentry track leading to the preferred landing site. This described method of corridor selection did not rely on or factor in the locations of minority or low-income populations.

3.5 GEOLOGY AND SOILS

Geologic resources consist of naturally formed minerals, rocks, and unconsolidated sediments. Soil refers to the uppermost layers of surficial geologic deposits and the weathering of those deposits. Concerns associated with the geologic setting, which could either affect or be affected by a proposed project, include on-and off-base topography and erosion on base.

3.5.1 On-Base Region

The geologic setting in the vicinity of Edwards AFB is characterized by three major rock types or geologic complexes: a basement complex of igneous and metamorphic rocks, an intermediate complex of continental volcanic and sedimentary rocks, and valley fill deposits. The basement complex is of pre-Tertiary age and includes quartz monzonite, granite, gneiss, schist, and other igneous and metamorphic rocks. These rocks crop out in the highlands surrounding the playa areas and occur beneath the unconsolidated deposits of the playa. The intermediate complex, with limited exposure in the Edwards AFB vicinity, is of Tertiary age and includes a variety of sedimentary and volcanic rock types (Dutcher and Worts 1963).

3.5.1.1 Topography

The U.S. Department of Agriculture (USDA) Natural Resource Conservation Service has completed a soil survey of Edwards AFB for the U.S. Army Corps of Engineers (USACOE). The *Grazing and Cropland Management Plan* for Edwards AFB describes results of this soil survey (USACOE 1997). Based on this survey, the soils at Edwards AFB can be characterized as predominantly alkaline, consisting of loams, sandy loams, and loamy sands, all of which are susceptible to wind and water erosion.

3.5.1.2 Erosion

According to the *Soil Survey of Edwards Air Force Base, California, Interim Report* (USDA Soil Conservation Service 1998) the soils at Edwards AFB are given erosion hazard ratings of slight to severe for wind erosion and slight to moderate for water erosion.

3.5.2 Off-Base Region

3.5.2.1 Alternative A (Western Approach)

The topography below the Alternative A corridor is a diverse mixture of desert, mountains, and valleys, often changing dramatically, especially within close proximity to the coast. There are also several islands scattered along the coast, the largest being the Channel Islands. Edwards AFB is located in the western portion of the Mojave desert and the area immediately surrounding the base is dominated by the Antelope Valley, which is bordered to the south by the San Gabriel Mountains, to the northwest by the Tehachapi Mountains, and to the east by low hills. Layers of eroded material from the surrounding mountains have built up over bedrock to form alluvial fans. These layers of rock, sand, and alluvium are shallow along the base of the mountains, rock outcroppings, and butte formations, and become deep in the dry lakes or playas. Rock outcroppings, ranging from small, single rocks to small mountain or ridge formations, spot the ground surface (NASA/Dryden Flight Research Center 1999).

Northwest of Edwards AFB the Tehachapi Mountains rise to almost 8,000 feet in places (Double Mountain). Due west of the Tehachapi Mountains begins the Sierra Madre Range, which merges with the Santa Ynez Mountains and the Panza Range, both of which parallel the coastline. Significant peaks in this area are Mount Pinos (8,831 feet), Frazier Mountain (8,026 feet), Reyes Peak (7,510 feet), and Monte Arido (6,003 feet).

Northwest of the Tehachapi Mountains the terrain flattens out into desert in the arid inland strip that Interstate 5 follows north toward Sacramento. West of the interstate, steep hills rise to become the lower portion of the Diablo Range, and finally, further west the Santa Lucia Range begins, which parallels the coastline between the Monterey-San Luis Obispo County line and Monterey Bay (American Automobile Association 2001).

3.5.2.2 Alternative B (Northwestern Approach)

The topography beneath the Alternative B corridor includes desert, mountains, and valleys of all sizes. Immediately surrounding the base is the western portion of the Mojave Desert, as described for Alternative A. North of the Mojave Desert are the Sierra Nevada, a massive mountain range stretching 350 miles from the Cascade Range to the Mojave, north to south, and averaging 50 miles wide between the western portion of Nevada and California's Central Valley, east to west (U.S. Geological Survey [USGS] 2001).

The southern portion of the Sierra Nevada has peaks well over 14,000 feet, including Mount Whitney (14,494 feet), which is the highest peak in the lower 48 states. The northern portion of the Sierra Nevada blends with the Salmon Mountains to the west and the Warner Mountains to the east until reaching the Oregon border, which marks the beginning of the Cascade Range. Mount Shasta (14,162 feet) is the highest peak in northern California.

The Cascade Province forms an arc-shaped band extending from British Columbia to Northern California, roughly parallel to the Pacific Coastline. Within this province lie 13 major volcanic centers, including Mount St. Helens, Mount Rainier, and Mount Hood. Beyond the Oregon border the Cascade Range spans the entire length of the state, north to south, and within this portion of Alternative B are dozens of peaks above 9,000 feet.

3.6 HAZARDOUS WASTE/HAZARDOUS MATERIALS

For purposes of this analysis, the terms "hazardous material" and "hazardous waste" are those substances defined by the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and the Resource Conservation and Recovery Act (RCRA).

A hazardous material is any material whose physical, chemical, or biological characteristics, quantity, or concentration may cause or contribute to adverse effects in organisms or their offspring; pose a substantial present or future danger to the environment; or result in damage to or loss of equipment, property, or personnel.

Hazardous wastes are substances that have been "abandoned, recycled, or are inherently waste like," and that (because of their quantity, concentration, or characteristics) may cause increases in mortality or serious irreversible illness, or pose a substantial hazard to human health or environment if improperly treated, stored, transported, or disposed of.

Solid waste refers to non-hazardous garbage, refuse, sludge, and any other discarded solid material resulting from residential, commercial, and industrial activities or operations. Solid waste can be classified as construction/demolition waste, non-hazardous recyclable waste, or non-hazardous non-recyclable waste.

3.6.1 Hazardous Materials

Edwards AFB uses a wide variety of hazardous materials in support of research activities on base and its mission requirement to support all types of aircraft. Hazardous materials are used for aircraft repair and maintenance, aircraft launch and recovery, aerospace ground equipment repair and maintenance, building remodeling, and construction. Some of the most commonly used hazardous materials include jet and motor fuel, other types of petroleum products, paints, thinners, adhesives, cleaners, lead-acid batteries, hydraulic fluids, and halogenated and non-halogenated solvents (U.S. Air Force 1995).

Hazardous materials are used to support rocket propulsion research and development at the Air Force Research Lab (AFRL). Typical hazardous materials used include liquid and solid rocket propellants. Other hazardous materials used at the AFRL include batteries, antifreeze, cleaning/degreasing solvents, and machinery lubricants, which are used in component fabrication, repair, maintenance, and assembly operations (AFFTC 1998a).

The types of hazardous materials most commonly used during construction projects include acids, corrosives, caustics, glycol, compressed gases, paints and paint thinners, solvents, sealant, adhesives, cements, caulking, fire retardant, and hot asphalt (140^{0}F or greater). Building and facility maintenance requires the use of heating fuels, paints, aerosols, and fluorescent light bulbs, all of which are hazardous materials.

Implementation of the Hazardous Materials Pharmacy approach accomplishes several important management goals, including reducing the volume of hazardous materials purchased and hazardous wastes generated through improved materials management. Edwards AFB uses the pharmacy concept to issue hazardous materials for use by Air Force personnel. The Hazardous Materials Pharmacy monitors shelf life and tracks usage of hazardous materials on base. One common database is used to manage issued hazardous material products. Hazardous materials purchased through the pharmacy are bar code labeled upon their arrival at Supply Central Receiving and distributed to the various satellite issue points or Hazardous Materials Distribution Support Centers located throughout Edwards AFB.

All organizations and contractors are required to maintain strict inventories of all their hazardous materials. Furthermore, organizations are also required to reduce the quantity of hazardous materials used or replace them with non-hazardous material, if possible, as a part of the Pollution Prevention Program. Guidelines used by Edwards AFB include Air Force Instruction 32-7086*, Hazardous Materials Management*; Air Force Instruction 32-7042*, Solid and Hazardous Waste Compliance*; and AFFTC Instruction 23-1*, Hazardous Material Management Program.*

3.6.2 Hazardous Waste

Hazardous materials/waste recycling is addressed in 22 California Code of Regulations (CCR) 66266.1–66266.130; Assembly Bill 3474; and the California Health and Safety Code, Section 26143.2. This includes commercial chemical products; used or contaminated solvents (halogenated, oxygenated, hydrocarbon); used or unused petroleum products; pickling liquor; unspent acids; unspent alkalis; and unrinsed empty containers of iron or steel used for pesticides or other hazardous chemicals.

The use of hazardous materials results in generation of hazardous waste (e.g., paint waste, used oil, contaminated rags), which requires proper handling. The U.S. EPA enforces the RCRA (40 CFR 260–272), which provides guidelines for the generation, storage, transportation, and disposal of hazardous waste. The California Environmental Protection Agency (Cal EPA) enforces hazardous waste laws embodied in 22 CCR Chapters 10–20 and the California Health and Safety Code (Section 25100). Environmental Management at Edwards AFB manages hazardous waste accumulation. Guidelines used by Edwards AFB include the *Edwards Air Force Base Hazardous Waste Management Plan* (AFFTC 1998a), which was prepared in accordance with Air Force Instruction 32-7042*, Solid and Hazardous Waste Compliance*. It establishes procedures to achieve compliance with applicable federal, state, and local regulations for hazardous waste management, except munitions, explosives, biohazard, and radioactive waste. Specifically, it contains requirements for solid and hazardous waste characterization, training, accumulation, turn-in and disposal, as well as procedures for inspections, permits, and record keeping.

Geologic resources (i.e., soil and groundwater) are susceptible to contamination from the surface. Releases of hazardous chemicals such as petroleum products and solvents have resulted in soil contamination at military installations. Contaminated soil or groundwater may require physical removal or extensive remediation to ensure the protection of public health and safety.

The Installation Restoration Program (IRP) was established to identify, investigate, assess, and clean up hazardous waste at former disposal sites on the base in compliance with CERCLA. Under the IRP, a

Preliminary Assessment was conducted at Edwards AFB to locate potential areas of concern (AOCs) that may have resulted from past activities on the 301,000-acre base.

Edwards AFB has identified 471 IRP sites and AOCs with potential contamination. The IRP sites at Edwards AFB are grouped into 10 Operable Units (OUs), generally based on geographic location. IRP sites, AOCs, and OUs are shown in Figures 3-9 and 3-10. Runway 22 lies within OU2, several IRP sites are located adjacent to the runway.

3.6.3 Solid Waste

Edwards AFB operates a non-hazardous (municipal solid) waste landfill within the Main Base area. At current disposal rates, the landfill is expected to reach permitted capacity in the year 2019. Due to the volume of construction/demolition waste generated on base, most current construction contracts require the contractor to dispose of such wastes at an approved off-base landfill in order to reduce the impacts to the Main Base Landfill.

The base actively participates in a recycling program, which is operated by a contractor with program oversight provided by Environmental Management. Some waste metals generated during construction and demolition projects, as well as the routine operations of various base organizations, are diverted to the Defense Reutilization and Marketing Office for resale.

3.7 INFRASTRUCTURE

Infrastructure refers to the physical components that are used to deliver something (e.g., electricity, traffic) to the point of use. Elements of infrastructure typically include energy, water, wastewater, electricity, natural gas, liquid fuel distribution systems, communication lines (e.g., telephone, computer), and circulation systems (streets and railroads).

3.7.1 On-Base Region

3.7.1.1 Energy Resources

The general policy of the Air Force regarding energy is as follows:

> Energy is essential to the Air Force's capability to maintain peacetime training, readiness, and credible deterrence; to provide quality of life; and to perform and sustain wartime operations. In short, energy is an integral part of the weapon system. The most fundamental Air Force energy policy goal is to ensure energy support to the national security mission of the Air Force in a manner which emphasizes efficiency of use, effectiveness of costs, and independence from foreign sources for mission-essential operations… (AFFTC 1995).

Edwards AFB uses electricity, solar power (e.g., photovoltaic panels to run traffic lights and heat water), natural gas/propane and other petroleum-based products (gasoline, jet fuel, and diesel) as sources of energy to operate facilities, vehicles, equipment, and aircraft.

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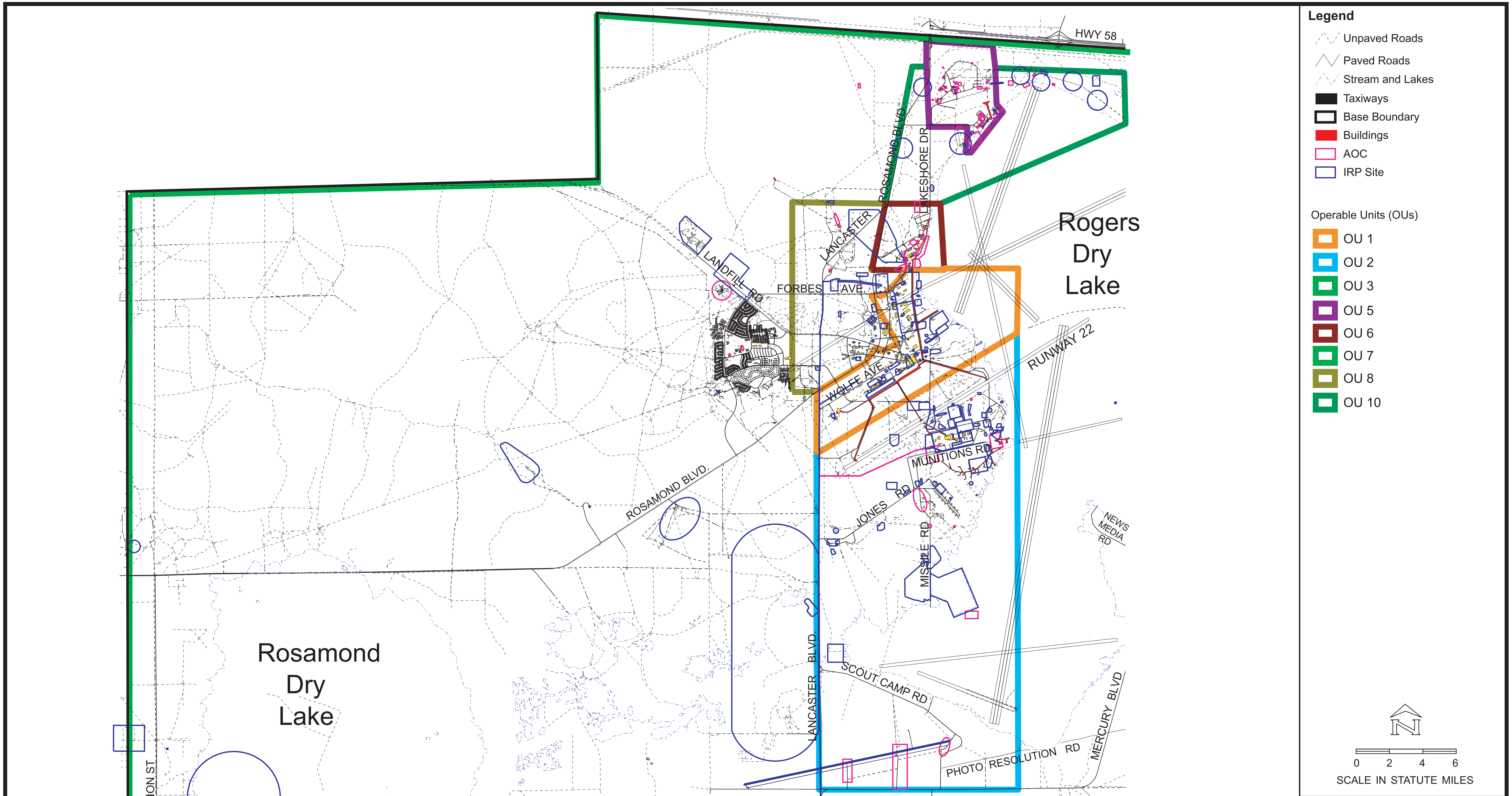
Legend
Unpaved Roads
Paved Roads
Stream and Lakes
Taxiways
Base Boundary
Buildings
AOC
IRP Site
Operable Units (OUs)
OU 1
OU 2
OU 3
OU 5
OU 6
OU 7
OU 8
OU 10
N
0 2 4 6
SCALE IN STATUTE MILES
HWY 58
ROSAMOND BLVD
LAKESHORE DR
LANCASTER
LANDFILL RD
FORBES AVE.
Rogers Dry Lake
RUNWAY 22
WOLFE AVE
MUNITIONS RD
ROSAMOND BLVD.
JONES RD
NEWS MEDIA RD
MISSILE RD
Rosamond Dry Lake
LANCASTER BLVD
SCOUT CAMP RD
PHOTO RESOLUTION RD
MERCURY BLVD
DIVISION ST
C AVE.
90TH ST
140TH ST
E. E

EA for the Orbital Reentry Corridor for
Generic Unmanned Lifting Entry Vehicle
Landing at Edwards AFB

SITES, AREAS OF CONCERN,
AND OPERABLE UNITS
AT EDWARDS AFB (WEST)

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TC#	DATE	DRAWN BY	FILENAME	FIGURE NO.
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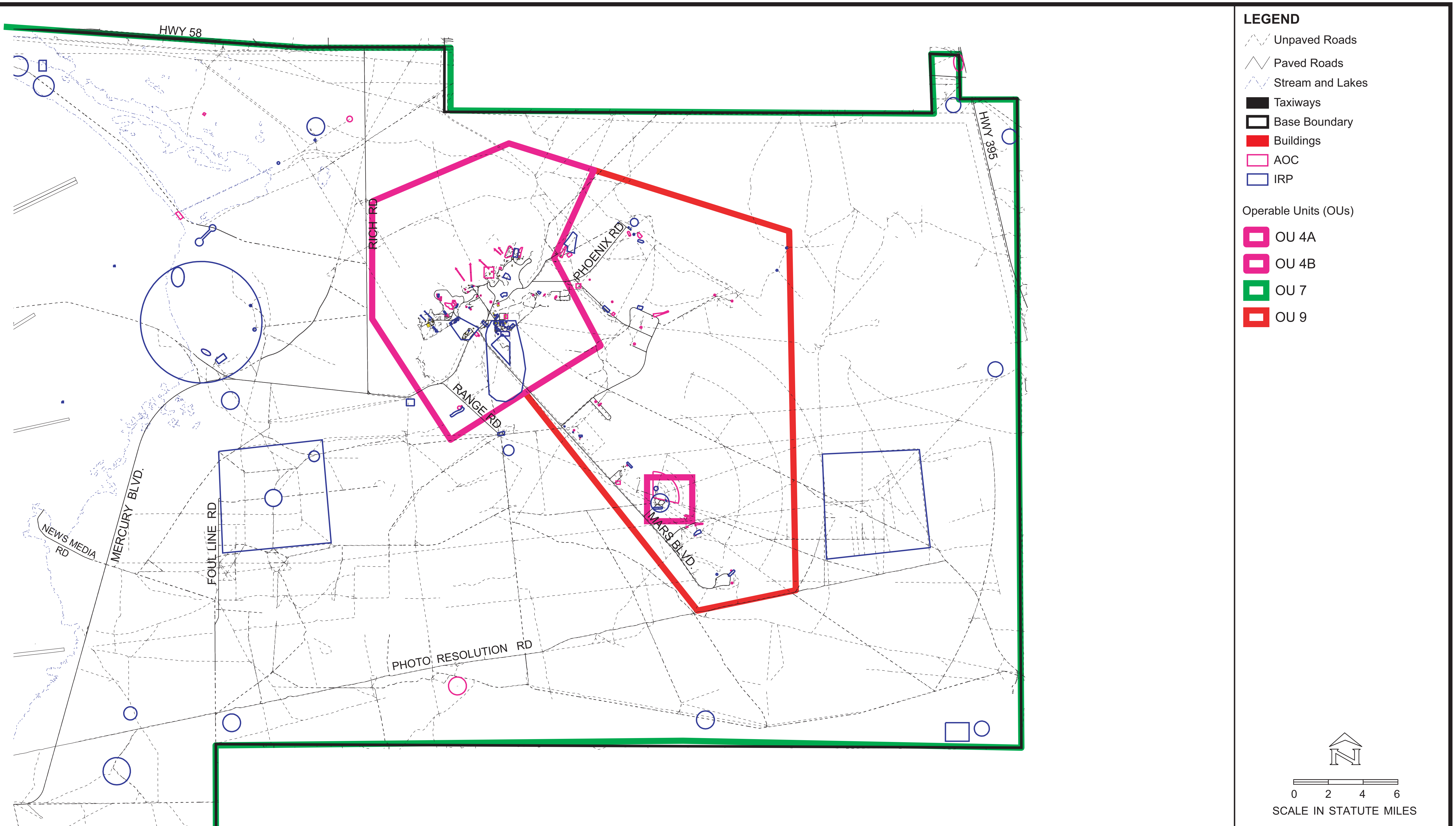
LEGEND
Unpaved Roads
Paved Roads
Stream and Lakes
Taxiways
Base Boundary
Buildings
AOC
IRP
Operable Units (OUs)
OU 4A
OU 4B
OU 7
OU 9
HWY 58
HWY 395
RICH RD
PHOENIX RD
RANGE RD
MARS BLVD
MERCURY BLVD.
NEWS MEDIA RD
FOUL LINE RD
PHOTO RESOLUTION RD
N
0
2
4
6
SCALE IN STATUTE MILES

EA for the Orbital Reentry Corridor for
Generic Unmanned Lifting Entry Vehicle
Landing at Edwards AFB

SITES, AREAS OF CONCERN,
AND OPERABLE UNITS
AT EDWARDS AFB (EAST)

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Southern California Edison provides electricity to Edwards AFB. The base uses this energy source to operate a variety of systems including lighting, heating and cooling, computers, and pumps for gas and water. Pacific Gas and Electric supplies natural gas to Edwards AFB. The base uses natural gas to run boilers, furnaces, and two standby generators. Propane is used in areas where natural gas services are unavailable and is used to operate one standby generator. Edwards AFB uses solar energy for hot water and forced air heating systems; to provide light (i.e., skylights); and to operate the emergency phone system on major portions of Rosamond, Lancaster, and Mercury Boulevards.

Edwards AFB is responsible for approximately 13.4 miles of petroleum pipeline used to transport JP-8 jet fuel to various locations throughout the Base. The supply pipeline for the base is the CalNev Pipeline. Edwards AFB receives JP-8 fuel from a spur line from the George AFB terminal.

3.7.1.2 Water Distribution System

The AFFTC purchases potable water from the Antelope Valley East Kern (AVEK) Water Agency. This water is distributed through a system located in Boron, California. The water distribution system for Edwards AFB consists of a series of pipes ranging in size from 4 to 24 inches in diameter, booster pump stations, and storage tanks. Five storage tanks, three at the Main Family Housing area and two at North Base, provide a potable water storage capacity of 4.3 million gallons. Additional storage tanks dedicated to fire suppression are located throughout the base. The distribution system, although presently adequate, requires continuous repairs and replacement to sustain its capacity (AFFTC 1997a).

3.7.1.3 Wastewater/Storm Water

There are two sanitary sewer collection and treatment systems on Edwards AFB. These systems service the Main, North, and South Base areas and the AFRL. The collection network for the existing system is composed of gravity lines, force mains, and pump stations. The Main Base Waste Water Treatment Plant provides tertiary treatment of wastewater.

The storm water distribution system at Edwards AFB consists of conveyance structures and drainage ditches (unpaved). Storm water conveyance structures include channels, gutters, drains, and sewers (not tied into the sanitary sewer system) that collect storm water runoff and direct its flow. The storm water system at Main Base conveys storm water to a pretreatment facility, which consists of an oil-water separator and an evaporation pond (AFFTC 1998b). Storm water from the undeveloped portions of the base flow into the nearest dry lake (AFFTC 1994).

3.7.1.4 Communication Systems

Communication systems on Edwards AFB include telephone, microwave, and local area networks. The distribution system for these systems generally consists of copper-pair cable, fiber-optic cable, and a communication manhole/conduit system.

3.7.1.5 Transportation Systems

Edwards AFB is accessed by way of Rosamond Boulevard from the west or north, and by Lancaster Boulevard/120th Street East from the south. Primary access to Edwards AFB from the adjacent roadways is by way of North Gate, West Gate, and South Gate, each of which is in operation 24 hours a day, 7 days a week. All gates contain two inbound and two outbound lanes (USACOE and AFFTC 1994).

Internal circulation on base is by way of paved and unpaved primary, secondary, and tertiary roads. Primary roads connect Edwards AFB components such as the flightline, Engineering and Administration, and support areas to entry points. Secondary roads connect Edwards AFB components to one another and support facilities such as commercial or housing areas. Tertiary roads are unpaved access roads or residential streets within the housing area (AFFTC 1997b).

The primary base streets currently carry all rush-hour traffic without significant congestion problems. The traffic flow at the West Gate is approximately 5,300 vehicles daily or 40 percent of total base traffic volume. The South Gate has a traffic flow of approximately 4,600 vehicles daily or 34 percent of the total base traffic volume. The North Gate services approximately 3,500 vehicles daily or 26 percent of the total. The West Gate provides the best free flow during morning rush-hour traffic, while the South and North Gates allow sufficient flow without exceeding design capacity.

Traffic consists of government, contractor, and privately owned vehicles belonging to those that live and/or work on base. In addition, commercial vehicles deliver material to businesses and facilities in the area. Commercial and Air Force vehicles are used for service and construction work done in the area. Emergency vehicles require access to all buildings and roads.

In addition to the paved roadways, an extensive network of unimproved, dirt roadways exists, essentially equivalent to the paved network. These roads have posted speed limits and provide access to various installation facilities and sites.

Two railroads are adjacent to the base. The Southern Pacific line runs parallel to the base's west boundary and adjacent to Sierra Highway. The north/south main line does not provide service to Edwards AFB. The Atchison, Topeka, and Santa Fe Railroad is located south of California Highway 58 and along the northern boundary of the Base. Two rail spurs, one at Edwards Station and the other at Boron Station connect to the Main Base and AFRL, respectively (AFFTC 1994).

3.7.2 Off-Base Region

Areas within the reentry corridors for Alternatives A and B sustain widespread infrastructure, including traffic circulation systems such as highways and byways, unpaved roads, non-maintained roads, railroad lines, and any other system involved in mass transportation.

Hundreds of miles of road and railroad traverse the land beneath the Alternative A and B corridors. Interstate 5, State Highway 101, and State Route 99 are the largest roads within both of these corridors. Amtrak, Union Pacific Railroad Company, and the Burlington Northern & Santa Fe Railway Company are the largest railroad operators within these corridors. Many regional, local, and switching and terminal lines are also found here, including a railroad.

Within the Alternative A and B corridors are cities, towns, and rural communities of all sizes, throughout which are extensive communication systems; industrial complexes with factories and power plants; energy distribution systems for electricity, natural gas, liquid fuels, and nuclear, solar, hydro, and wind power; water treatment facilities; and waste management facilities.

In addition, there are many pipelines for crude oil transportation, operated by All American, Chevron, Four Corners, Exxon/Mobil, Shell, Texaco, Unocal, ARCO, and Pacific Texas. In addition, Calnev, Shell, and Kinder Morgan operate product transportation pipelines throughout the ROIs (Department of Energy [DOE] 2001).

Diablo Canyon Nuclear Power Plant, located in Avila Beach, is the only nuclear generating station within the ROI of the proposed project. It lies under the Alternative A Corridor, though there are many natural gas and electric plants, and energy related infrastructure that occur within the area beneath the Alternative A and B corridors (DOE 2001).

The offshore region sustains significantly less infrastructure than inland, but there is heavy traffic from commercial shipping, commercial fishing, and watercraft of all kinds. The offshore region also contains 24 oil and gas facilities between Point Dume and Eureka, California, although most of them are along the southern coast. There are oil ports within the ROI (Channel Islands; San Francisco Bay area; and Portland, Oregon), as well as coastal factories and power plants, and communication systems.

3.8 LAND USE

Land may be used for a variety of purposes including residential, industrial, commercial, agricultural, recreational, and military. Specialized land uses may include radio transmission areas, bombing/missile ranges, wildlife preserves, explosive ordnance ranges, and airfields.

3.8.1 On-Base Region

Edwards AFB is situated in Kern, Los Angeles, and San Bernardino counties, approximately 60 miles northeast of the city of Los Angeles. The base consists of approximately 300,800 acres of largely undeveloped or semi-improved land that is used to support the flight testing of a wide variety of military, civilian, and experimental aircraft. The developed portion of the base includes approximately six percent of the total base area, and is concentrated on the west side of Rogers Dry Lake. Developed areas include Main Base, North Base, South Base, Family Housing areas, and the AFRL. The *Edwards Air Force Base Comprehensive Plan* describes long-range development for Edwards AFB, establishing goals, policies, plans, and anticipated action regarding the physical, social, and economic environment (AFFTC 1994). Land use designations, including total acreage and the percent of the base area, are described in Table 3-8 (AFFTC 1994).

Table 3-8
Land Use Designations at Edwards AFB

Land Use Designation	Total Square Miles	Total Acres	Percentage of Total Base Property (%)
Aircraft Clearance, Quantity-Distance	4.86	3,110.40	1.00
Aircraft Pavement, Runways	0.91	582.40	0.20
Lakebed Painted Runways	3.12	1,996.80	0.070
Lakebed Nonmaintained Landing Site	61.00	39,040.00	13.00
Aircraft Operations and Maintenance/Engineering Test	27.83	17,811.20	5.90
Aircraft Test Ranges	336.23	215,187.20	71.50
Industrial	12.18	7,795.20	2.60
Administrative	0.19	121.60	0.04
Community Commercial	0.21	134.40	0.04
Community Service	0.30	192.00	0.10
Medical	0.07	44.80	0.01
Housing	1.52	972.80	0.30
Outdoor Recreation	3.83	2,451.20	0.80
Buffer Zone	17.75	11,360.00	3.80
Water	0.00	0.00	0.00
Total	**470**	**300,800**	**100**

Within these various land use designations, specific areas have been set aside for a particular purpose. These include, but are not limited to, the off-road vehicle areas I and II, the Combat Arms Range, hunting and fishing areas, the Precision Impact Range Area, and the AFRL.

A portion of Edwards AFB is designated for the NASA DFRC, which is a major installation on base, covering 838 acres. DFRC's existing land-use plan divides its facility into three basic use zones: (1) the flightline, (2) support services, and (3) explosive hazard zones. The flightline zone is adjacent to Rogers Dry Lake, is restricted to flight research activities, and includes aircraft hangars, test facilities, pavement, and runways. Support services are behind the flight line zone and include warehouses, project support complexes, and administrative support. Western Aeronautical Test Range zones include a remote site and a small triangular section of the facility adjacent to Lily Avenue that includes a radio tower. The remote site includes the facility's water tower and several radio towers. The two explosive hazard zones overlap the flight line and support services zone. These two circular zones extend for a minimum distance of 1,200 feet from the shuttle loading area (NASA/Dryden Flight Research Center 1999).

3.8.1.1 Land Use Restrictions

Air Force land use policies and guidance are only applicable to lands under their control. Policies established by the Air Force for airfields are similar to the criteria established by the FAA for development of surrounding civilian airports. Air Force Joint Manual 32-1013, *Airfield and Heliport*

Planning and Design Criteria, sets the minimum requirements for airfields and applicable land uses for surrounding areas. The Edwards AFB Planning and Zoning Committee grants final siting approval for all construction and activity-related projects as part of the review and approval process.

Edwards AFB has three paved runways that provide the principal landing surfaces for the base. These runways are divided into two different classes: A and B. The primary difference between class A and B runways is in the type of aircraft used on the runway. Class A runways are primarily intended for small, light aircraft. Class B runways are primarily intended for high performance and large, heavy aircraft. The Main Base Runway (Runway 22) is a Class B runway and is the primary airstrip on base. The runways on North and South Base are class A. In addition, the base has 18 runways painted on dry lakebeds and uses the remaining lakebed areas for emergency landings.

Land use controls around airfields and lakebeds are recommended by the air installation compatible use zone (AICUZ). The AICUZ delineates areas at both ends of a runway, called accident potential zones (APZs), where the probability of aircraft accidents is highest based on statistical analysis of past accident data at various bases.

A clear zone is an area on the ground or water beginning at the end of the runway and symmetrical about its center. This zone is to be free of obstacles for the purpose of protecting the safety of approaching aircraft. The clear zone for a class A runway is 1,000 feet wide by 3,000 feet long. The clear zone for a class B runway is 3,000 feet wide by 3,000 feet long.

Accident potential zones I and II, located beyond the clear zone, possess a significant potential for accidents. Each zone has associated land use restrictions and its size is dependent upon a variety of factors defined in Air Force Joint Manual 32-1013*, Airfield and Heliport Planning and Design Criteria*. The following land uses are generally compatible with APZ I: industrial, agricultural, recreational, and vacant land. In addition to compatibility with APZ I land uses, APZ II also includes low-intensity residential and nonresidential uses for a maximum of 20 percent building coverage per acre.

Explosive hazard or quantity-distance zones are associated with test areas and areas for explosives, munitions, and propellant storage. These zones vary in size depending upon the quantity and type of explosive being used or stored. Zoning ensures the safety of all personnel within a given area. Typical areas where these zones exist include the unconventional fuels area, the explosive ordnance disposal area, the gun-butt and munitions storage area, the arm/de-arm areas, the hot cargo area, and the AFRL. The ROI for the proposed action includes all explosive hazard and quantity distance zones on base, as well as those in the immediate vicinity of Runway 22.

3.8.1.2 Airfield Operations

Flightline operations are carried out by the 412th Test Wing (412 TW) and the 95th Air Base Wing (95 ABW). The 412 TW is the direct mission organization of the AFFTC, which is responsible for testing and evaluating manned and unmanned aerospace vehicles, subsystems, and components. The 95 ABW is the support unit on Edwards AFB responsible for communications; civil engineering; transportation, including loading and unloading armament and supplies; fuel supply; security police; and fire protection.

The 412th Operations Group (412 OG) plans and conducts all flight test activities for the 412 TW. The 412 OG also advises the 412 TW on air traffic control matters and airfield and airspace management including flight management. Ridley Mission Control Center is the central safety coordination point for all operations affecting the Precision Impact Range Area.

3.8.1.3 Visual and Aesthetic Resources

A Scenic Quality Map for Edwards AFB, created by the Bureau of Land Management (BLM) Visual Resource Management Program, divides the base into sub-units and rates them according to the following factors: landform, vegetation, water, color, influence of adjacent scenery, scarcity, and cultural modification.

Class A areas contain a combination of the most outstanding characteristics of each rating factor. There are no Class A areas on base. Class B areas contain a combination of some outstanding features and features fairly common to the physiographic region. Areas with lakebeds, the more scenic and relatively undisturbed hills and ridges, the denser Joshua Tree woodlands, and Leuhman Ridge on base fall into Class B. Class C areas contain features fairly common to the physiographic region and include the remainder of the base, with the exception of the developed areas. Class D areas are so heavily developed and/or extensively disturbed that they lack positive aesthetic attributes, thereby diminishing the visual quality of surrounding areas. These areas include North Base, JPL, NASA, Main Base, South Base, housing, and the AFRL (AFFTC 1994).

Edwards AFB contains two areas with special ecological concerns: desert tortoise critical habitat, and Significant Ecological Areas (SEAs). These areas are discussed further in Section 3.9, Natural Resources.

3.8.2 Off-Base Region

3.8.2.1 Alternative A (Western Approach)

The Alternative A ROI extends from Edwards AFB to the Pacific coast, east to west, and from Monterey to Point Dume, north to south. The area encompasses approximately 6,494 square miles. Visual and aesthetic resources in this region fall under several different designations including national forest; national monument; national, state, and county parkland; BLM land; wilderness areas; wild and scenic rivers; national trails; and privately owned land.

Various off-base aircraft restrictions apply to inland and offshore visual and aesthetic resources.

Inland Region

The land below the Alternative A corridor includes many visual and aesthetic resources including all of Santa Barbara and San Luis Obispo Counties, most of Monterey County, approximately half of Kern and Ventura Counties, and small portions of Kings and Tulare Counties. The corridor's boundary also cuts through the uppermost portion of Los Angeles County, although these areas are either mostly National Forest lands or other lands that are relatively unpopulated. Table 3-9 lists the distribution of city populations among each county.

Visual and aesthetic resources beneath the Alternative A corridor include three national forests, one national monument, five national wildlife refuges, BLM land, two military installations, and six wilderness areas. Table 3-10 shows the location and regulating agency for each federal area, and provides a comparison of land acreage.

Located throughout the area below the Alternative A corridor are 19 state parks, 16 state beaches, 3 state reserves, 9 state historic parks, and several county parks. These areas are generally in or near highly populated regions.

U.S. Forest Service Land, National Wildlife Refuges, National Parks, California State parks, Areas of Special Biological Significance, Ecological Reserves, and Biospheres do not regulate aircraft overflights.

Offshore Region

The offshore region consists of coastal lands, coastal waters, islands, and open ocean. A wide variety of activities occur within the offshore ROI including recreation, commercial fishing and mariculture, commercial shipping, offshore oil and gas activity, and research and education projects. There is also a significant portion of private coastal land within the offshore region. Major portions of the coast are designated Marine Protected Areas or fall under the ownership and/or management of Channel Islands National Park, Channel Islands National Marine Sanctuary, Monterey Bay National Marine Sanctuary, and Vandenberg AFB.

It is unlawful to fly motorized aircraft, except as necessary for valid law enforcement purposes, at less than 1,000 feet above the Monterey Bay National Marine Sanctuary. In the Channel Islands National Marine Sanctuary, seabirds or marine mammals may not be disturbed by flying motorized aircraft at less than 1,000 feet over the waters within 1 nautical mile of any island except for law enforcement purpose. For the California Sea Otter Game Refuge it is unlawful to fly any aircraft or helicopter less than 1,000 feet above water or land, except for rescue operations, in case of any emergency, or for scientific purposes under a permit issued by the California Department of Fish and Game (CDFG). The Marine Resources Protection Act Ecological Reserve has restrictions stating that no person shall operate any aircraft or hovercraft within an ecological reserve, except as authorized for scientific research approved by the CDFG. Similarly, within the San Miguel, Santa Barbara, and Anacapa Island Ecological Reserves, it is unlawful to fly any aircraft or helicopter less than 1,000 feet above water or land, except for any rescue operations, in case of any emergency, or for scientific purposes under a permit issued by the CDFG.

National Parks, California State parks, Areas of Special Biological Significance, Marine Life Refuges, Fish Refuges, Ecological Reserves, State Reserves, Underwater Parks, Clam Refuges, and Biospheres do not regulate aircraft overflights.

Table 3-9
Population Distribution Under the Alternative A Corridor

County (Population)	City (Within ROI)	City Population
Ventura (753,197)	Oxnard	170,358
	Thousand Oaks	117,005
	Simi Valley	111,351
	San Buenaventura	100,916
	Camarillo	57,077
	Moorpark	31,415
	Santa Paula	28,598
	Port Hueneme	21,845
	Fillmore	13,643
	Ojai	7,862
	Mira Monte	7,177
	El Rio	6,193
	Oak View	4,199
	Meiners Oaks	3,750
	Casa Conejo	3,180
	Oak Park	2,320
	Piru	1,196
Kern (661,645)	Bakersfield	247,057
	Delano	38,824
	Oildale	27,885
	Ridgecrest	24,927
	Wasco	21,263
	Rosamond	14,349
	Lamont	13,296
	Arvin	12,956
	Shafter	12,736
	Tehachapi	10,957
	Rosedale	8,445
	California City	8,385
	Taft	6,400
	Mojave	3,836
	Ford City	3,512
	Weldon	2,387
	Frazier Park	2,348
	Wofford Heights	2,276
	Boron	2,025
	Lost Hills	1,938
	Bodfish	1,823
	Kernville	1,736

Table 3-9, Page 1 of 3

Table 3-9 (Continued)
Population Distribution Under the Alternative A Corridor

County (Population)	City (Within ROI)	City Population
Kern (Continued)	Buttonwillow	1,266
	North Edwards	1,227
	Inyokern	984
	Onyx	476
	Keene	339
	Randsburg	77
Monterey (401,762)	Salinas	151,060
	Monterey Park	60,051
	Seaside	31,696
	Marina	25,101
	Pacific Grove	15,522
	Greenfield	12,583
	Soledad	11,263
	King City	11,094
	Gonzales	7,525
	Castroville	6,724
	Carmel Valley Village	4,700
	Carmel-by-the-Sea	4,081
	San Ardo	501
	Spreckels	485
	San Lucas	419
	Bradley	120
Santa Barbara (399,347)	Santa Barbara	92,325
	Santa Maria	77,423
	Goleta	55,204
	Lompoc	41,103
	Isla Vista	18,344
	Carpinteria	14,194
	Vandenberg AFB	6,151
	Guadalupe	5,659
	Solvang	5,332
	Santa Ynez	4,584
	Buellton	3,828
	Los Alamos	1,372
	Santa Ynez Reservation	566
Tulare (368, 021)	Visalia-Tulare-Porterville	368,021

Table 3-9, Page 2 of 3

Table 3-9 (Continued)
Population Distribution Under the Alternative A Corridor

County (Population)	City (Within ROI)	City Population
San Luis Obispo (246,681)	San Luis Obispo	44,174
	Atascadero	26,411
	Arroyo Grande	15,851
	Grover Beach	13,067
	Nipomo	12,626
	Morro Bay	10,350
	Cambria	6,232
	Pismo Beach	8,551
	Templeton	4,687
	San Miguel	1,427
	Shandon	986
Kings (129,481)	Hanford	41,686
	Lemoore	19,712
	Avenal	14,674
	Corcoran	14,458
	Armona	3,239
	Kettleman City	1,499
	Stratford	1,264

Table 3-9, Page 3 of 3
Source: U.S. Census Bureau 2000.

Table 3-10
Federal Land Ownership in the Off-Base Region Under the Alternative A Corridor

Name	County	Acreage	Agency Responsible	Land Use
Los Padres National Forest	Monterey, San Luis Obispo, Santa Barbara, Ventura	1,754,780	U.S. Forest Service (USFS)	Recreation, timber harvesting, mining, rangeland, hydroelectric production
Sequoia National Forest	Kern, Tulare	327,769	USFS	Recreation, timber harvesting, mining, rangeland, hydroelectric production
Angeles National Forest	Los Angeles, Ventura	650,000	USFS	Recreation, timber harvesting, mining, rangeland, hydroelectric production
Pinnacles National Monument	Monterey	24,000	National Park Service Service (NPS)	Recreation, timber
Kern National Wildlife Refuge	Kern	10,618	U.S. Fish and Wildlife Service (USFWS)	Recreation, research, wildlife preservation
Pixley National Wildlife Refuge	Tulare	6,192	USFWS	Recreation, research, wildlife preservation
Bitter Creek National Wildlife Refuge	Kern, Santa Barbara, Ventura	14,000	USFWS	Research, wildlife preservation (California condor recovery site), limited recreation
Blue Ridge National Wildlife Refuge	Tulare	897	USFWS	Research, wildlife preservation (California condor recovery site), limited recreation
Hopper Mountain National Wildlife Refuge	Ventura	2,471	USFWS	Recreation, research, wildlife preservation
BLM Land	Monterey, San Luis Obispo, Santa Barbara, Ventura Kings, Tulare, and the western half of Kern	320,000 (approx)	Bureau of Land Management (BLM)	Recreation, timber harvesting, mining, rangeland, preservation
Ventana Wilderness	Monterey	216,500	USFS	Primitive recreation; preservation of scenic, scientific, or historic geology or ecology

Table 3-10, Page 1 of 2

Table 3-10 (Continued)
Federal Land Ownership in the Off-Base Region Under the Alternative A Corridor

Name	County	Acreage	Agency Responsible	Land Use
Dick Smith Wilderness	Santa Barbara	68,000	USFS	Primitive recreation; preservation of scenic, scientific, or historic geology or ecology
Garcia Mountain Wilderness	San Luis Obispo	14,100	USFS	Primitive recreation; preservation of scenic, scientific, or historic
Manchesna Mountain Wilderness	San Luis Obispo	20,000	USFS	Primitive Recreation; preservation of scenic, scientific, or historic geology or ecology
San Rafael Wilderness	Santa Barbara	217,000	USFS	Primitive recreation; preservation of scenic, scientific, or historic geology or ecology
Santa Lucia Wilderness	San Luis Obispo	21,678	USFS	Primitive recreation; preservation of scenic, scientific, or historic geology or ecology
Vandenberg AFB	Santa Barbara, Monterey	86,000	U.S. Air Force	Military operations
Hunter-Liggett Reserve	San Luis Obispo	165,000	U.S. Army Reserves	Military operations

Table 3-10, Page 2 of 2

Sources: National Park Service 2001; U.S. Forest Service 2001

3.8.2.2 Alternative B (Northwestern Approach)

The Alternative B ROI stretches diagonally from Edwards AFB in southeastern California to the northwestern portion of Oregon just below the Columbia River. The northern and southern boundaries along the coast are the Columbia River and the Humboldt-Del Norte county line, respectively. Alternative B encompasses approximately 56,129 square miles. Land in this region falls under several different designations including national forest; national monument; national, state, and county parkland; BLM land; wilderness areas; wild and scenic rivers; national trails; and privately owned land.

Various off-base aircraft restrictions apply to inland and offshore visual and aesthetic resources.

Inland Region

The land below the Alternative B corridor provides many visual and aesthetic resources within 52 counties: 24 in California, 3 in Nevada, and 19 in Oregon. For a list of counties and populations see Table 3-11.

The land underneath the Alternative B corridor consists of 21 national forests, 6 national parks, 2 national recreation areas, 3 national monuments, 1 national memorial, 15 national wildlife refuges, 1 national grassland, and hundreds of thousands of acres of BLM land. Table 3-12 shows the location and regulating agency for each federal area, and provides a comparison of land acreage.

Also scattered throughout the corridor are state parks, beaches, reserves, historic parks, recreation areas, and county parks. These areas are generally in or near highly populated regions.

U.S. Forest Service Land, National Wildlife Refuges, National Parks, California State parks, Areas of Special Biological Significance, Ecological Reserves, and Biospheres do not regulate aircraft overflights.

Offshore Region

The offshore region consists of coastal lands, coastal waters, islands, and open ocean. A wide variety of activities occur within the offshore ROI including recreation, commercial fishing and mariculture, commercial shipping, offshore oil and gas activity, and research and education projects. There is also a significant portion of private coastal land within the offshore region. The coastline is over 340 miles long and the offshore region extends up to 1,500 miles out to sea. Major portions of the coast are designated Marine Protected Areas or are under the ownership and/or management of Redwood National Park, Olympic Coast National Marine Sanctuary, and Oregon Dunes National Recreation Area.

It is unlawful to fly motorized aircraft less than 2,000 feet above the Olympic Coast National Marine Sanctuary. National Parks, California State parks, Areas of Special Biological Significance, Marine Life Refuges, Fish Refuges, Ecological Reserves, State Reserves, Underwater Parks, Clam Refuges, and Biospheres do not regulate aircraft overflights.

Table 3-11
Population Distribution Under Alternative B Corridor

Counties

CALIFORNIA

County	Population
Fresno	799,401
Kern	661,645
Tulare	368,021
Placer	248,399
Butte	203,171
Shasta	163,256
El Dorado	156,299
Humboldt	126,518
Madera	123,109
Nevada	92,033
Yuba	60,219
Tehama	56,039
Tuolumne	54,501
Siskiyou	44,301
Calaveras	40,554
Amador	35,100
Lassen	33,828
Del Norte	27,507
Glenn	26,453
Pumas	20,824
Mariposa	17,130
Trinity	13,022
Mono	12,853
Modoc	9,449
Sierra	3,555
Alpine	1,208
Total	3,398,395

OREGON

County	Population
Multinomah	660,486
Washington	445,342
Clackamas	338,391
Lane	322,959
Marion	284,834
Jackson	181,269
Linn	103,069
Douglas	100,399
Yamhill	84,992
Benton	78,153
Josephine	75,726
Klamath	63,775
Coos	62,779
Polk	62,380
Lincoln	44,479
Columbia	43,560
Clatsop	35,630
Tillamook	24,262
Curry	21,137
Total	3,033,622

NEVADA

County	Population
Douglas	41,259
Storey	3,399
Washoe	339,486
Total	384,144

Major Cities

CALIFORNIA

City	Population
Redding	80,865
Chico	59,954

OREGON

City	Population
Eugene	137,893
Salem	136,924
Medford	63,154
Klamath Falls	19,462

NEVADA

City	Population
Carson City	52,457

Note: County population data represent totals for each county. Data have not been adjusted to coincide with the boundaries of azimuth range 325 to 337 degrees, which do not include the whole area of every county.

Table 3-12
Federal Land Ownership in the Off-Base Region Under the Alternative B Corridor

Name	**State**	**Acreage**	**Agency Responsible**
Deschutes National Forest (NF)	OR	183,000	USFS
El Dorado NF	CA	123,631	USFS
Fremont NF	OR	1,000,000	USFS
Humboldt-Toyabe NF	CA/NV	6,300,000	USFS
Humboldt-Trinity NF	CA		USFS
Klamath NF	OR/CA		USFS
Lassen NF	CA		USFS
Mendocino NF	CA	1,000,000	USFS
Modoc NF	CA		USFS
Plumas NF	CA	1,000,000	USFS
Rogue River NF	OR	630,000	USFS
Sequoia NF	CA	327,769	USFS
Shasta-Trinity NF	CA	2,000,000	USFS
Sierra NF	CA	1,300,000	USFS
Siskiyou NF	OR/CA	1,163,484	USFS
Siuslaw NF	OR	620,000	USFS
Six Rivers NF	CA		USFS
Stanislaus NF	CA		USFS
Tahoe NF	CA		USFS
Umpqua NF	OR	1,000,000	USFS
Willamette NF	OR	1,600,000	USFS
Winema NF	OR	1,100,000	USFS
Ankeny National Wildlife Refuge (NWR)	OR		USFWS
Bandon Marsh NWR	OR		USFWS
Baskett Slough NWR	OR		USFWS
Bear Valley NWR	CA	4,200	USFWS
Cape Mears NWR	OR		USFWS
Clear Lake NWR	CA	40,000	USFWS
Klamath Forest NWR	OR		USFWS
Lower Klamath NWR	CA	53,598	USFWS
Modoc NWR	CA	6,283	USFWS
Oregon Islands NWR	OR		USFWS
Sacramento River NWR	CA		USFWS
Tule Lake NWR	CA	39,116	USFWS
Upper Klamath NWR	CA	14,917	USFWS
William L. Finly NWR	OR		USFWS

Table 3-12, Page 1 of 2

Table 3-12 (Continued
Federal Land Ownership in the Off-Base Region Under the Alternative B Corridor)

Name	State	Acreage	Agency Responsible
Butte Valley National Grasslands	CA	18,425	USFS
Carlton Lake Game Refuge	OR		
South Slough Estuarine Research Reserve	OR	4,700	NOAA
Devil's Post Pile National Monument	CA	800	
Fort Clatsop National Monument	OR	NA	
Oregon Caves National Monument	OR	NA	
Oregon Dunes National Recreation Area (NRA)	OR		USFS
Smith River NRA	CA	305,000	USFS
Crater Lake National Park (NP)	OR		NPS
Kings Canyon/Sequoia NP	CA	863,700	NPS
Lassen Volcanic NP	CA	106,000	NPS
Redwood NP	CA	40 miles on the Pacific Coast	NPS
Yosemite NP	CA	1,200 (sq. miles)	NPS

Table 3-12, Page 2 of 2

Notes: CA – California
NF - National Forest
NOAA - National Oceanic and Atmospheric Administration
NP - National Park
NPS - National Parks Service
NRA - National Recreation Area
NV - Nevada
OR - Oregon
USFS - U.S. Forest Service

Sources: National Park Service 2001; USDA Forest Service 2001.

3.9 NATURAL RESOURCES

Biological resources are defined as the terrestrial and aquatic ecosystems with the native plants and animals that occur throughout these ecosystems. This includes plant populations and communities; wildlife populations and their relationship to habitat; and aquatic, wetland, and riparian ecosystems. Plant and animal species that are proposed for, candidates for, or are listed as, threatened or endangered by the U.S. Fish and Wildlife Service (USFWS), and species having equivalent status at the California state level, are referred to as special-status species and are given special consideration by law for their preservation.

Critical habitat for a threatened or endangered species is defined under the federal Endangered Species Act (ESA) as specific areas within the geographical area occupied by the species at the time it is listed that contain the physical or biological features that are essential to the conservation of the species and may require special management considerations or protection, and specific areas outside the geographic area occupied by the species at the time it is listed that are also essential to the conservation of the species.

The USFWS identifies primary physical and biological constituent elements of an area designated as critical habitat that are essential to the conservation of the species (50 CFR 424.12). Primary constituent elements may include, but are not limited to, roost sites, nesting grounds, spawning sites, feeding sites, seasonal wetlands or drylands, water quality or quantity, host species or plant pollinators, geological formations, vegetation types, tides, and specific soil types (50 CFR 424.12).

Federal agencies are required by Section 7 of the ESA to assess the effect of any project on federally listed threatened and endangered species. Under Section 7, consultation with the USFWS is required for federal projects if such actions could directly or indirectly affect listed species or destroy or adversely modify critical habitat; a conference is required if such action could directly or indirectly affect a proposed listed species or proposed critical habitat. It also is Air Force policy to follow management goals and objectives specified in Integrated Natural Resources Management Plans, and to consider sensitive species, sensitive communities, and habitats recognized by state and local agencies when evaluating impacts of a project.

3.9.1 On-Base Region

3.9.1.1 Plants

Plant Communities

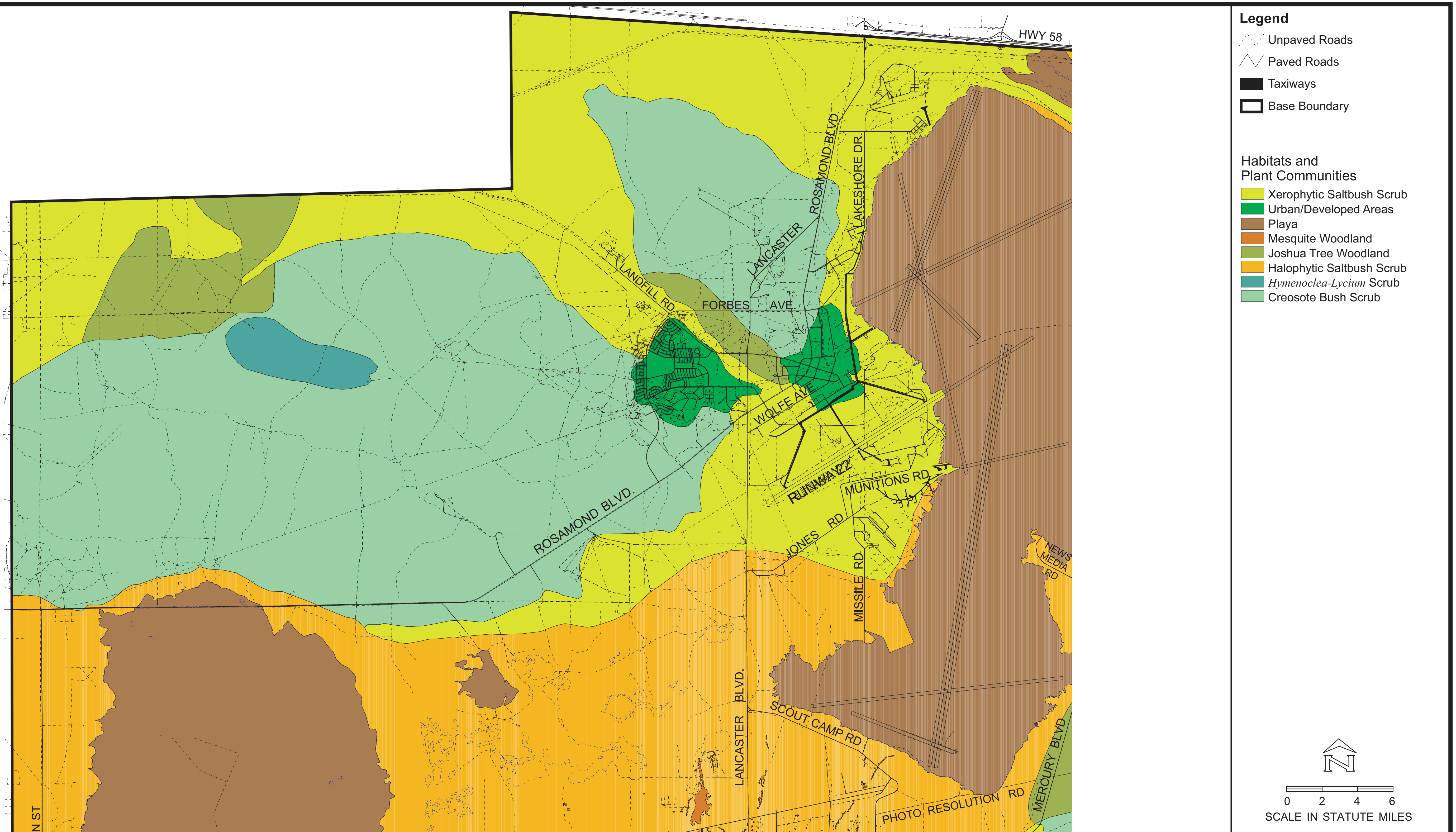
The five major plant communities at Edwards AFB are creosote bush scrub, Joshua tree woodland, halophytic phase saltbrush scrub, xerophytic saltbush scrub, and mesquite woodland (Figures 3-11 and 3-12).

Creosote bush scrub is dominated by creosote bush (*Larrea divaricata*). At Edwards AFB, there are approximately 103,000 acres of creosote bush scrub, which comprises approximately 34 percent of the area of the base. Common species found in this community include winterfat (*Ceratoides lanata*), cheesebush (*Hymenoclea salsola*), and Nevada tea (*Ephedra nevadensis*).

Joshua tree woodland is dominated by Joshua trees (*Yucca brevifolia*). At Edwards AFB, there are approximately 52,800 acres of Joshua tree woodland, which comprises approximately 17 percent of the area of the base. Common species found in this community include the native desert dandelion (*Malacothrix glabrata*), pincushion (*Chaenactis* sp.), and fiddleneck (*Amsinckia tesselata*).

Halophytic phase saltbush scrub is dominated by four species of the genus *Atriplex*: spinescale (*A. spinifera*), shadscale (*A. confertifolia*), four-wing saltbush (*A. canescens*), and quailbush (*A. lentiformes*). At Edwards AFB, there are approximately 55,300 acres of halophytic phase saltbush scrub, which comprises approximately 18 percent of the area of the base. A common species found in this community includes saltgrass (*Distichlis spicata*).

Arid phase saltbush scrub is dominated by allscale (*Atriplex polycarpa*). At Edwards AFB, there are approximately 45,300 acres of arid phase saltbush scrub, which comprises approximately 15 percent of the area of the base. Common species found in this community include burrobush (*Ambrosia dumosa*), goldenhead (*Acamptopappas sphaerocephalus*), and cheesebush (*Hymenoclea salsola*).


Legend
Unpaved Roads
Paved Roads
Taxiways
Base Boundary
Habitats and Plant Communities
🟩 Xerophytic Saltbush Scrub
🟩 Urban/Developed Areas
🟫 Playa
🟧 Mesquite Woodland
🟩 Joshua Tree Woodland
🟨 Halophytic Saltbush Scrub
🟦 *Hymenoclea-Lycium* Scrub
🟩 Creosote Bush Scrub
N
0 2 4 6
SCALE IN STATUTE MILES
HWY 58
ROSAMOND BLVD
LAKESHORE DR.
LANCASTER
LANDFILL RD
FORBES AVE.
WOLFE AVE
RUNWAY 22
MUNITIONS RD
ROSAMOND BLVD.
JONES RD
MISSILE RD
NEWS MEDIA RD
LANCASTER BLVD.
SCOUT CAMP RD
MERCURY BLVD
PHOTO RESOLUTION RD
DIVISION ST
C AVE.
90TH ST
140TH ST
E. E

EA for the Orbital Reentry Corridor for Generic Lifting Vehicle Landing at Edwards AFB

HABITATS AND PLANT COMMUNITIES AT EDWARDS AFB (WEST)

Tetra Tech, Inc. Santa Barbara, CA
4213 State Street, Suite 100
Santa Barbara, CA 93110-2847

TC#	DATE	DRAWN BY	FILENAME	FIGURE NO.
Q202-0501	2/21/02	IGE	GRAPHIC:\ Edwards AFB\Reentry 3-11 Plants West.ai	3-11

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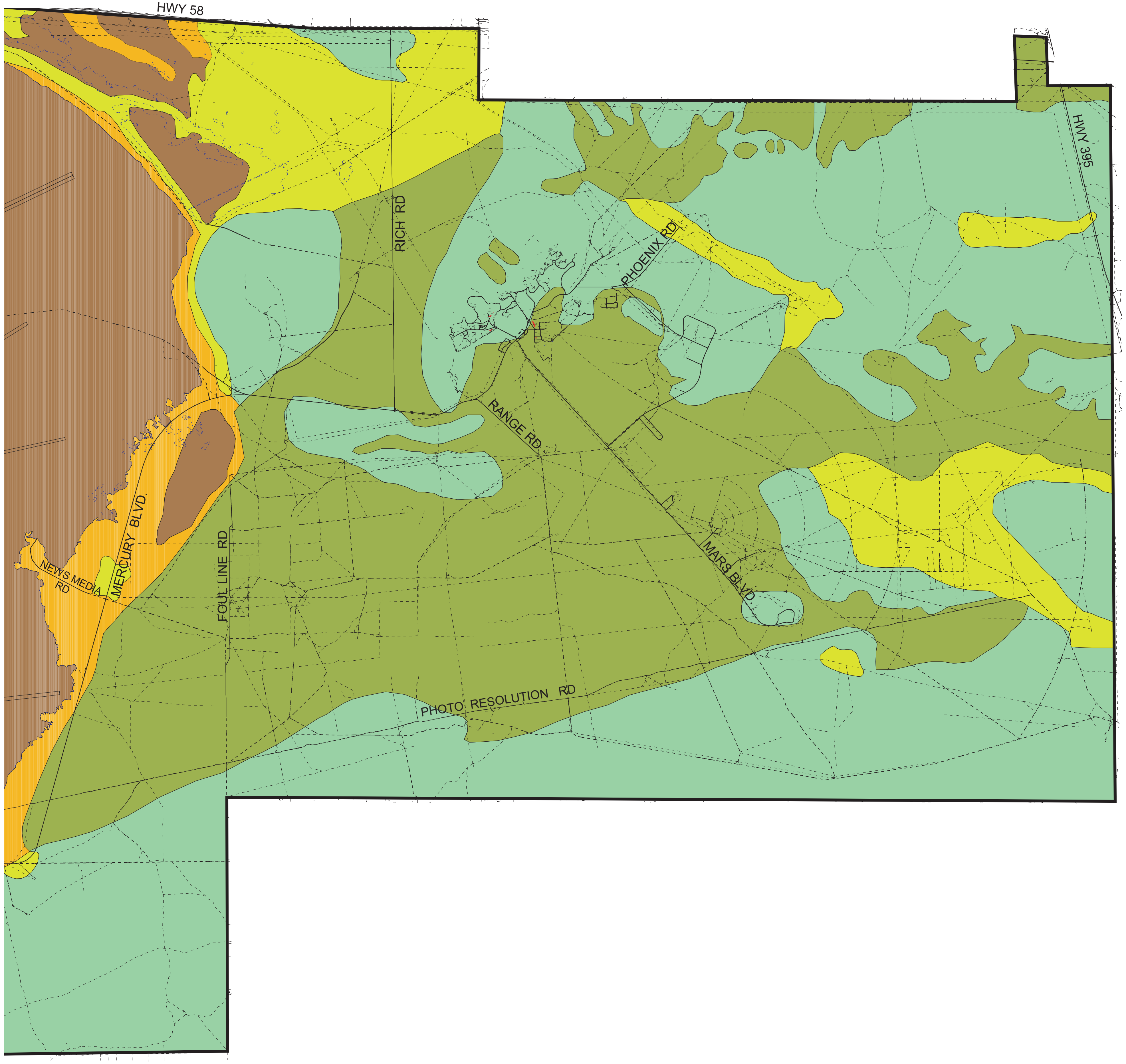
HWY 58
HWY 395
RICH RD
PHOENIX RD
RANGE RD
MERCURY BLVD.
NEWS MEDIA RD
FOUL LINE RD
MARS BLVD
PHOTO RESOLUTION RD

Legend

Unpaved Roads
Paved Roads
■ Taxiways
□ Base Boundary

Habitats and
Plant Communities

🟨 Xerophytic Saltbush Scrub
🟩 Urban/Developed Areas
🟫 Playa
🟧 Mesquite Woodland
🟩 Joshua Tree Woodland
🟧 Halophytic Saltbush Scrub
🟦 *Hymenoclea-Lycium* Scrub
🟩 Creosote Bush Scrub

N

0 2 4 6

SCALE IN STATUTE MILES

EA for the Orbital Reentry Corridor for
Generic Unmanned Lifting Entry Vehicle
Landing at Edwards AFB

HABITATS AND
PLANT COMMUNITIES
AT EDWARDS AFB (EAST)

Tetra Tech, Inc.
4213 State Street, Suite 100
Santa Barbara, CA 93110-2847

TC#	DATE	DRAWN BY	FILENAME	FIGURE NO.
Q202-0701	11/6/02	RANDALL	GRAPHIC:\ Edwards AFB\Reentry\ 3-12 Plants East.ai	3-12

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Sensitive Plant Species

Studies of sensitive plants on Edwards AFB indicate that no federal or state-listed plant species have been identified on base. Nine species that are listed by the California Native Plant Society (CNPS), however, have been identified on base. Four of these plants are Barstow woolly sunflower (*Eriophyllum mohavense*), desert cymopterus (*Cymopterus deserticola*), alkali mariposa lily (*Calochortus striatus*), and yellow spiny cape (*Goodmania luteola*).

3.9.1.2 Wildlife

Five eubranchiopod shrimp species have been identified in Rogers Dry Lake: clam shrimp (*Eocyzicus digueti*), tadpole shrimp (*Lepidurus lemmoni*), and three species of fairy shrimp (*Branchinecta mackini*, *B. gigas*, and *B. lindahli*) (AFFTC 1992). Eubranchiopods lie dormant in the soil of dry lakebeds until flooding creates the aquatic habitat necessary to complete their life cycles. These shrimp are a food source for a variety of migratory shorebirds that congregate at Rogers Dry Lake when water is present.

To date, the only amphibians identified on base include the western toad (*Bufo boreas*), Pacific tree frog (*Hyla regilla*), red-spotted toad (*Bufo punctatus*), and African clawed frog (*Xenopus laevis*). These were identified at Piute Ponds by U.S. Geological Survey biologists during a survey in 1997. The African clawed frog is a problematic introduced species that feeds on native wildlife, including other amphibians, small reptiles, and fish (AFFTC 1997c). Common reptiles on base include the desert spiny lizard (*Sceloporus magister*), side-blotched lizard (*Uta stansburiana*), western whiptail (*Cnemidophorus tigris*), zebra-tailed lizard (*Callisaurus draconoides*), glossy snake (*Arizona elegans*), coachwhip (*Masticophis flagellum*), gopher snake (*Pituophis melanoleucus*), and the Mojave green rattlesnake (*Crotalus scutulatus*).

Common birds include the turkey vulture (*Cathartes aura*), common raven (*Corvus corax*), sage sparrow (*Amphispiza belli*), barn owl (*Tyto alba*), house finch (*Carpodacus mexicanus*), and western meadowlark (*Sturnella neglecta*). Joshua tree woodlands support cactus wren (*Campylorhynchus brunneicapillus*) and ladder-backed woodpecker (*Picoides scalaris*). Common bird species found in creosote scrub include the horned lark (*Eremophila alpestris*), black-throated sparrow (*Amphispiza bilineata*), and sage sparrow. The seasonal inundation of lakebeds and claypans attracts wading bird species, including the black necked stilt (*Himantopus mexicanus*), American avocet (*Recurvirostra americana*), and greater yellowlegs (*Tringa melanoleuca*). Birds associated with ponds include the yellow-headed blackbird (*Xanthocephalus xanthocephalus*), black-crowned night heron (*Nycticorax nycitorax*), and green heron (*Butorides striatus*).

Horned larks are commonly found in open habitat with sparse vegetation or areas of low shrubs (i.e., open field, agricultural areas, desert habitat, prairies, and grassland communities). The main runways on base are surrounded by arid phase saltbush scrub. Combined with open areas along the flightline, this habitat is suitable for horned larks. The vegetation adjacent to the runways is periodically graded, creating a buffer area devoid of vegetation, which also provides additional foraging habitat for horned larks. Methods that have been used at Edwards AFB to control the bird airstrike hazard problem with horned larks include revegetation with native plants and the use of a falconer.

The storm water retention pond along the flightline attracts other types of birds (e.g., waterfowl, shorebirds, etc.) and possibly bats that are associated with aquatic habitats. Barn owls (*Tyto alba*) are known to inhabit buildings on the flightline. During the evening, owls feed on small rodents adjacent to the runways and in other areas nearby.

Common mammals on Edwards AFB include the black-tailed jackrabbit (*Lepus californicus*), desert cottontail (*Sylvilagus audobonii*), and coyote (*Canis latrans*). Common rodents include the deer mouse (*Peromyscus maniculatus*), grasshopper mouse (*Onychomys torridus*), little pocket mouse (*Perognathus longimembris*), Merriam's kangaroo rat (*Dipodymus merriami*), and desert woodrat (*Neotoma lepida*). Common bats include the western pipistrelle (*Pipistrellus hesperus*) and little brown bat (*Myotis lucifugus*).

Sensitive Wildlife Species

The desert tortoise is listed as threatened by the federal government and by the State of California. It can occur throughout the Colorado and Mojave deserts in elevations up to 4,100 feet, although ideal habitat typically occurs between 1,000 and 3,000 feet (Edwards AFB 2001a). The desert tortoise can occur in almost every desert habitat, but is most common in desert washes, desert scrub, creosote bush, and Joshua tree habitats. This species finds cover in burrows that are usually under bushes and requires loose, dry, sandy soil for nest building. The desert tortoise is a herbivorous reptile whose native range includes the Sonoran and Mojave deserts of southern California, southern Nevada, Arizona, extreme southwestern Utah, and Sonora and northern Sinaloa, Mexico. Desert tortoises are known to live on Edwards AFB and the ROI includes suitable desert tortoise habitat.

Designated Critical Habitat

In 1994, the USFWS designated portions of the base as desert tortoise critical habitat (USFWS 1994). The boundary designated as desert tortoise critical habitat encompasses approximately 60,800 acres in the eastern and southeastern portions of Edwards AFB (Figures 3-13 and 3-14). The proposed project occurs in the airspace above the desert tortoise critical habitat. However, desert tortoise critical habitat does not occur in the proposed landing areas for the LEV.

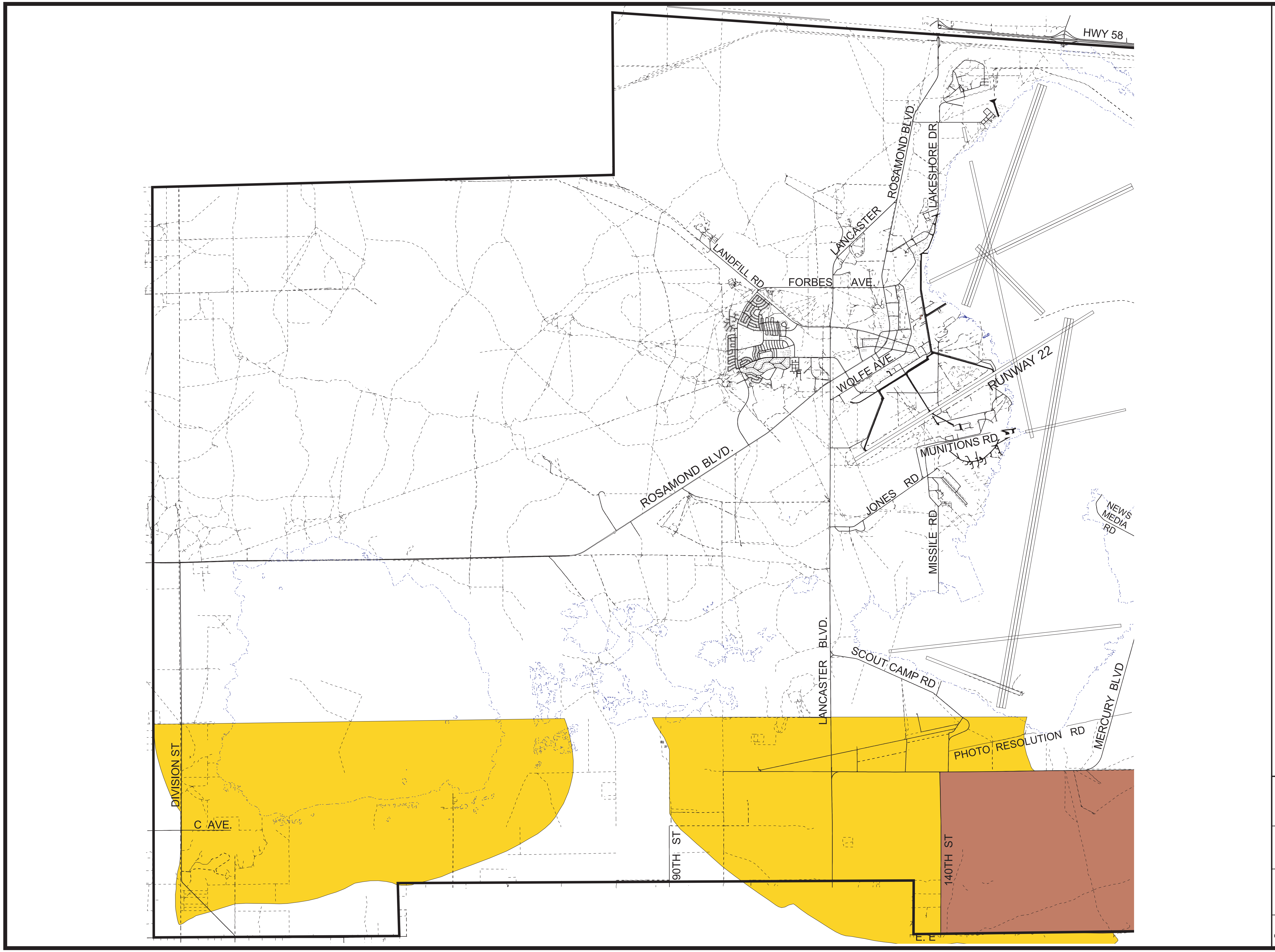
Migratory Birds

Seasonal migratory birds use both permanent and temporary bodies of water for foraging on shrimp and other food items at Edwards AFB. These birds include ducks and geese such as the ruddy duck (*Oxyura jamaicensis*), northern mallard (*Anas platyrhynchos*), northern pintail (*Anas acuta*), Canada goose (*Branta canadensis*), and snow goose (*Chen caerulescens*). Ducks and geese are hunted in designated areas on base.

3.9.1.3 Significant Ecological Areas

The *County of Los Angeles General Plan* establishes 61 SEAs, which represent a wide variety of biological communities within the county. The SEAs function to preserve this variety to provide a level of protection to the resources within them. The SEAs are intended to be preserved in an ecologically viable condition for the purposes of education, research, and other non-disruptive outdoor users, but are not intended to preclude limited compatible development.

Los Angeles County has identified two SEAs on Edwards AFB, Edwards Air Force Base (SEA #47) and Rosamond Lake (SEA #50). The locations of these SEAs are shown on Figures 3-13 and 3-14. SEA #47 contains botanical features that are unique and limited in distribution in Los Angeles County. They include the only good stands of mesquite (*Prosopis glandulosa*) in Los Angeles County. The area contains fine examples of creosote bush scrub, alkali sink, and the transition vegetation between the two. Mesquite woodlands provide habitat for a variety of mammals, birds, and reptiles.


HWY 58
ROSAMOND BLVD
LAKESHORE DR
LANCASTER
LANDFILL RD
FORBES AVE.
WOLFE AVE
RUNWAY 22
MUNITIONS RD
JONES RD
ROSAMOND BLVD.
MISSILE RD
NEWS MEDIA RD
LANCASTER BLVD.
SCOUT CAMP RD
MERCURY BLVD
PHOTO RESOLUTION RD
DIVISION ST
C AVE.
90TH ST
140TH ST
E. E

Legend

- ╱╲ Unpaved Roads
- ╱╲ Paved Roads
- ■ Taxiways
- □ Base Boundary

Sensitive Wildlife Habitat

- 🟫 Desert Tortoise Critical Habitat
- 🟨 Los Angeles County Significant Ecological Area (SEA)

N

0 2 4 6

SCALE IN STATUTE MILES

EA for the Orbital Reentry Corridor for Generic Lifting Vehicle Landing at Edwards AFB

SENSITIVE WILDLIFE HABITAT
AT EDWARDS AFB (WEST)

Tetra Tech, Inc. Santa Barbara, CA
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TC#	DATE	DRAWN BY	FILENAME	FIGURE NO.
Q202-0501	2/22/02	RANDALL	GRAPHIC:\ Edwards AFB\Reentry\ 3-13 SensHabWest.ai	3-13

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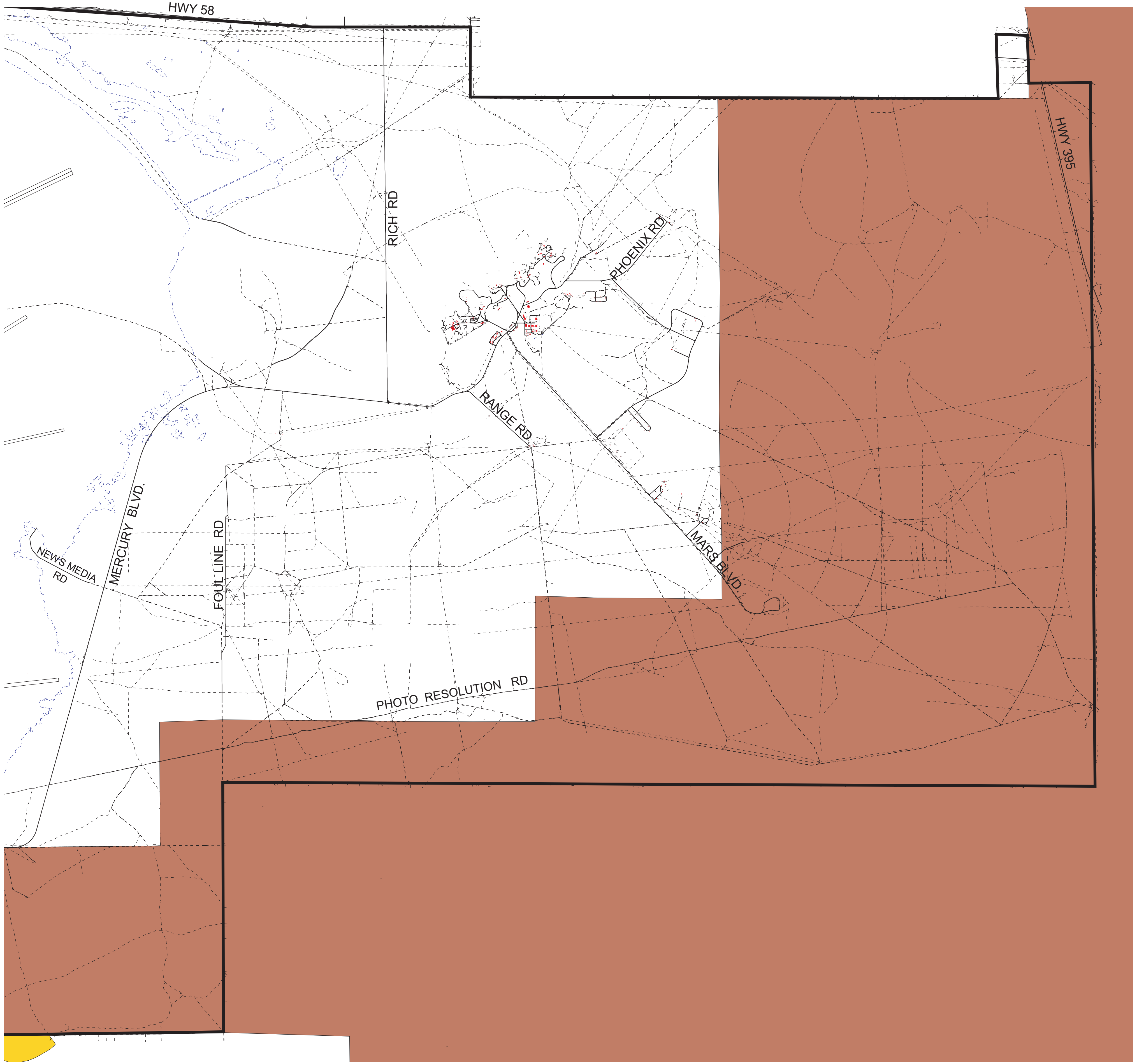
HWY 58
HWY 395
RICH RD
PHOENIX RD
RANGE RD
MARS BLVD.
MERCURY BLVD.
NEWS MEDIA RD
FOUL LINE RD
PHOTO RESOLUTION RD

Legend

- ⋰ Unpaved Roads
- ╱╲ Paved Roads
- ■ Taxiways
- ☐ Base Boundary

Sensitive Wildlife Habitat

- 🟫 Desert Tortoise Critical Habitat
- 🟨 Los Angeles County Significant Ecological Area (SEA)

N

0 2 4 6

SCALE IN STATUTE MILES

EA for the Orbital Reentry Corridor for Generic Unmanned Lifting Entry Vehicle Landing at Edwards AFB

SENSITIVE WILDLIFE HABITAT AT EDWARDS AFB (EAST)

Tetra Tech, Inc.

4213 State Street, Suite 100
Santa Barbara, CA 93110-2847

TC#	DATE	DRAWN BY	FILENAME	FIGURE NO.
Q202-0701	11/6/02	RANDALL	GRAPHIC:\ Edwards AFB\Reentry\ 3-14 SensHab East.ai	3-14

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The best example of shadscale scrub and alkali sink biotic communities in Los Angeles County are in SEA #50. It also contains Piute Ponds, which are located in the southwestern corner of the base. Piute Ponds support a variety of wildlife, especially birds. An important aspect of these ponds is that they provide a stopover area for migratory birds.

3.9.2 Off-Base Region

3.9.2.1 Alternative A (Western Approach)

Plants

A variety of plant communities occur throughout the land beneath the Alternative A corridor. These habitats may be dominated by trees, shrubs, or herbs, and may also include aquatic and developed habitats. Numerous sensitive plant species may occur beneath the off-base region of the Alternative A corridor.

Wildlife

Thirty-nine species of marine mammals inhabit the ROI, including year-round residents, occasional visitors and migratory species. Many of these species are listed as threatened, endangered, or species of concern and are protected under the ESA. All of these species are protected under the Marine Mammal Protection Act of 1972, and some are listed under this act as “depleted” or “strategic,” even though they may not be listed under the ESA.

Numerous other sensitive wildlife species occur beneath the off-base region of the Alternative A corridor. Designated critical habitat for various species exists in the off-base region beneath the Alternative A corridor.

The Pacific Flyway is a region of the Pacific coast that is utilized by thousands of migratory birds every year. This flyway begins in the western Arctic, extends to include the Pacific Coast regions of Canada, the United States and Mexico and continues south, where it combines with other flyways in Central and South America.

The Channel Islands and mainland coast act as a stopover during both north (April through May) and south (September through December) migrations. The months of June and July are peak months for transient shorebirds. The Channel Islands and the mainland coast also provide breeding and nesting sites for varying species and large numbers of seabirds, including threatened and endangered species.

3.9.2.2 Alternative B (Northwestern Approach)

Plants

A variety of plant communities occur throughout the land beneath the Alternative B corridor. These habitats may be dominated by trees, shrubs, or herbs, and may also include aquatic and developed habitats. Various sensitive plant species may occur in the area below the Alternative B corridor.

Wildlife

Thirty-nine species of marine mammals inhabit the ROI, including year-round residents, occasional visitors and migratory. Many of these species are listed as threatened, endangered, or species of concern and are protected under the ESA. All of these species are protected under the Marine Mammal Protection

Act, and some are listed under this act as “depleted” or “strategic,” even though they may not be listed under the ESA.

Numerous other sensitive wildlife species occur beneath the off-base region of the Alternative B corridor. Designated critical habitat for various species exists within the land beneath the Alternative B corridor. The Alternative B corridor also includes portions of the Pacific Flyway migratory bird corridor.

3.10 NOISE

3.10.1 Noise Characteristics

In 1972, Congress enacted the Noise Control Act (NCA), Public Law 92-574. Among the requirements under NCA was a directive to the U.S. EPA to “…publish information on the levels of environmental noise, the attainment and maintenance of which in defined areas under various conditions as requisite to protect the public health and welfare with an adequate margin of safety.” The U.S. EPA published EPA-550/9-47-004, *Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety*, in 1974 (Levels Document).

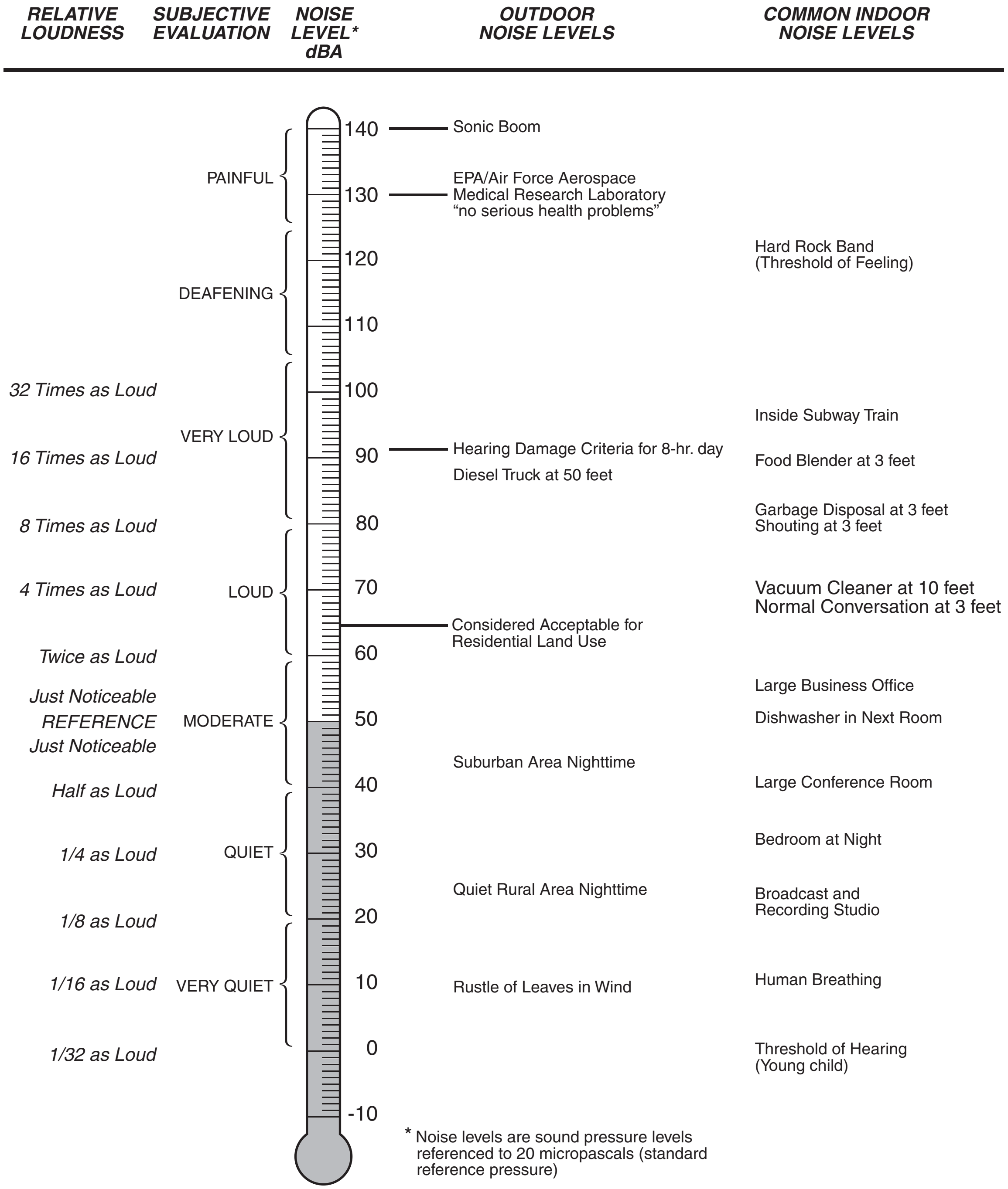
The characteristics of sound include parameters such as amplitude, frequency, and duration. The decibel (dB), a logarithmic unit that accounts for the large variations in amplitude, is the accepted standard unit measurement of sound. Different sounds may have different frequency content. When measuring sound to determine its effects of the human population, A-weighted sound levels (dBA) represent adjusted sound levels. The adjustments, created by the American National Standards Institute (1983), are established according to the frequency content of the sound. Examples of typical A-weighted sound levels are shown in Figure 3-15.

Noise is usually defined as sound that is undesirable because it interferes with communication and hearing, is intense enough to damage hearing ability, or is otherwise annoying. Noise levels often change with time. Therefore, to compare levels over different time periods, several descriptors were developed to account for the time variances. These descriptors are used to assess and correlate the various effects of noise on humans, including land use compatibility, sleep and speech interference, annoyance, hearing loss, and startle effects.

- A-weighted decibel scale (dBA). The A-weighted scale significantly reduces the measured pressure level for low frequency sounds while slightly increasing the measured pressure levels for middle frequency sounds. A-weighted sound levels are typically measured between 1,000 to 4,000 hertz (Hz).

- The long-term equivalent A-weighted sound level (Leq).

- Day-night average noise level (DNL). The DNL, often referred to as L_{dn}, has been adopted by federal agencies as the standard for measuring noise. The DNL is an A-weighted, 24-hour average of hourly averages. Each hourly average represents the sound energy of all the disparate sounds that occurred during that hour. The hourly average would be a continuous, uniform sound whose total sound energy would be equal to the sum of the individual sound energies of all the real sounds occurring during that hour. Typically, different hours of the day would have different hourly averages. For this reason, and for standardization, the DNL is defined as the average of the 24 hourly averages of the day.



* Noise levels are sound pressure levels referenced to 20 micropascals (standard reference pressure)

(SOURCE: U.S. Air Force 1975, 1978, no date [n.d.])

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Landing at Edwards AFB

EXAMPLES OF TYPICAL A-WEIGHTED SOUND LEVELS

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TASK NO.	DATE	DRAWN BY	AI FILE NO.	FIGURE NO.
Q202-0701	11/6/02	RANDALL	Graphic:\ EdwardsAFB\ Rentry\3-17 Noise Levels.ai	3-15

- C-weighted sound level. C-weighting measures sound levels in dB, with no adjustment to the noise level over most of the audible frequency range except for a slight de-emphasis of the signal below 100 Hz and above 3,000 Hz. C-weighting is used as a descriptor of low-frequency noise sources, such as blast noise and sonic booms.

- C-weighted day-night level (CDNL) is the C-weighted sound level averaged over a 24-hour period, with a 10-dB penalty added for noise occurring between 10:00 p.m. and 7:00 a.m. CDNL is similar to DNL, except that C-weighting is used rather than A-weighting.

- Sound exposure level (SEL) considers both the A-weighted sound level (AL) and duration of noise. SEL converts the total A-weighted sound energy in a given noise event with a given duration into a 1-second equivalent and, therefore, allows direct comparison between sounds with varying intensities and durations.

- C-weighted sound exposure level (CSEL) is an SEL measurement based on the C-weighted level rather than the A-weighted level.

- Sound pressure level (SPL) is a logarithmic scale, using dB as units, and a reference pressure that corresponds approximately to the minimum audible sound pressure.

- Community noise equivalent level (CNEL) has been adopted by the State of California as the descriptor for measuring noise levels. The CNEL is similar to the DNL, except that it includes a 5 dB penalty for evening noise (7:00 p.m. to 10:00 p.m.) in addition to the 10 dB “penalty” for nighttime noise.

In the Levels Document, the U.S. EPA reported that the best metrics to describe the effects of environmental noise in a simple, uniform, and appropriate way were:

- The L_{eq}; and

- The DNL or L_{dn} (a variant of L_{eq} that incorporates a 10-dB “penalty” for nighttime noise).

However, when high-intensity impulsive noise is evaluated to determine its effects on a human population, C-weighted sound levels are used so that the low-frequency effects of the noise are considered. The low-frequency content of impulsive noise contributes to effects such as window rattle that influence people’s perception of and reaction to the noise.

3.10.2 Existing Noise Setting

3.10.2.1 On-Base Region

Major noise sources at DFRC and Edwards AFB are aircraft operations that include rotary wing air traffic, engine testing, sonic booms, and vehicle traffic on streets. The major sources of motor vehicle-related noise at Edwards AFB are Lancaster Boulevard, Rosamond Boulevard, and primary and secondary streets on the base. The major source of motor vehicle-related noise near DFRC is Rosamond Boulevard.

Noise estimates are usually presented as noise contours. Noise contours are lines on a map of an airfield and its vicinity where the same noise level is predicted to occur. The 5-dB interval chosen to represent noise contours reflects the Department of Housing and Urban Development (HUD) noise criteria commonly used for airfield noise. Figure 3-16 presents CNEL noise contours at Edwards AFB.

As shown in Figure 3-16, Runway 22 noise contours for a CNEL of 60 dB and above lie completely within the boundary of Edwards AFB. Parts of the on-base recreation areas lie between the 65- and 70-dB contours. These areas include the Edwards AFB Rod and Gun Club (Combat Arms Range), base golf course, off-highway vehicle area number 1, and some of the picnic areas and athletic fields. The Main Base residential area is outside the 60-dB contour. The Main Base has a range of exposure from 65 to 85 dBs; the South Base 70 to 85 dBs. On-base land under the 80-dB noise contours is primarily open space and test program support areas. The South Base and a portion of the Main Base are currently within the 80-dB noise level; therefore, small areas of administrative, commercial, and industrial land are subject to these noise levels.

The area around Air Force Research Laboratory is subject to very high levels of noise during rocket engine tests. Test firings occur during daytime hours for 1 to 3 minutes on an infrequent basis. Personnel at the test site remain in buildings designed to protect them from high noise levels. Smaller engines are also tested at this location, and noise levels are less than half those produced by the large Titan engines. Approximately 1,750 people reside within the 80-dB contours of Titan test firings.

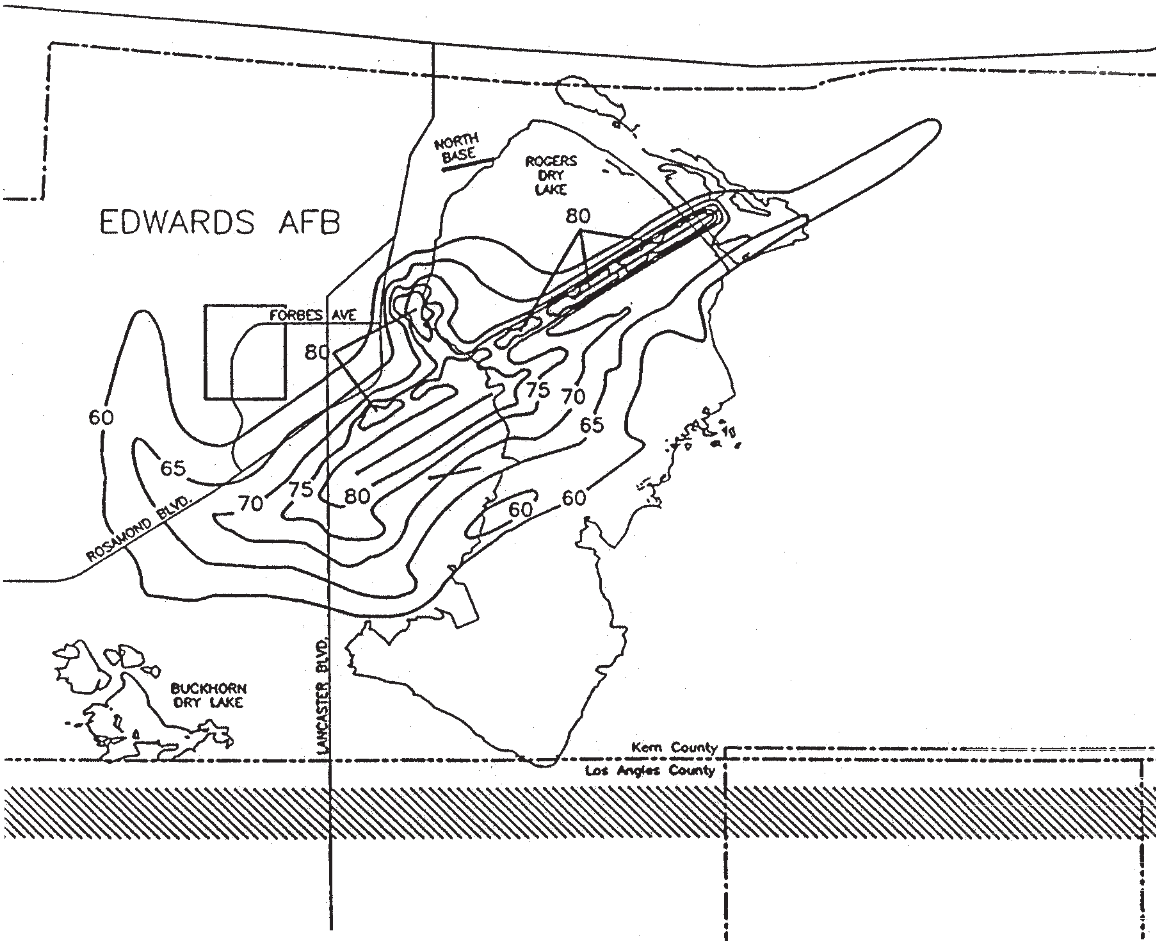
3.10.2.2 Off-Base Region

The off-base region under the corridors for Alternatives A and B consists primarily of open space, but includes major industrial, residential, commercial, and public/recreation centers as well. As shown in Figure 3-16, Runway 22 noise contours for 60-dB and above lie completely within the boundary of Edwards AFB, therefore, ambient noise levels in the off-base regions adjacent to Edwards AFB for Alternatives A and B are anticipated to be below a CNEL of 60-dB under normal conditions. However, there are areas within the off-base region where noise levels exceed 60-dB due to freeways, major highways, airports, and other noise-generating operations.

3.10.3 Project-Related Noise: Sonic Booms

As an aircraft or missile moves through the air, the air in front is displaced to make room for the vehicle and then returns once the vehicle passes. This causes what is called a sonic boom. In subsonic flight, a pressure wave (which travels at the speed of sound) precedes the vehicle and initiates the displacement of air around the vehicle. When a vehicle's speed reaches the speed of sound, it is said to be traveling at Mach 1. The pressure wave cannot travel faster than the speed of sound or precede the aircraft, and the parting process is abrupt. As a result, a shock wave is formed initially at the front of the aircraft when the air is displaced around it and lastly at the rear when a trailing shock wave occurs as the air recompresses to fill the void after passage of the vehicle.

A sonic boom differs from most other sounds because it is impulsive (similar to a double gunshot), there is no warning of its impending occurrence, and the magnitude of the peak levels is usually higher. Sonic booms are typically measured in dBC or by changes in air pressure, called peak overpressure (pounds per square foot). Factors that affect the nature and extent of sonic boom overpressures include aircraft design and operation, and atmospheric effects. Pressure waves are generated any time an object exceeds the speed of sound, and thus are generated for all supersonic flights. However, these pressure waves do not always propagate to the ground where they are perceived as a sonic boom. For a vehicle flying straight, the maximum sonic boom amplitudes will occur along the flight path


EDWARDS AFB
NORTH BASE
ROGERS DRY LAKE
80
FORBES AVE
80
75
70
65
60
65
70
75
80
60
60
ROSAMOND BLVD.
LANCASTER BLVD.
BUCKHORN DRY LAKE
Kern County
Los Angles County

LEGEND

- ▨ R–2515 Airspace Boundary
- Housing Area
- Installation Boundary
- County Boundary
- CNEL Noise Contours

N

Scale in Miles

0 1 2 3 4

EA for the Orbital Reentry Corridor for
Generic UNmanned Lifting Entry Vehicle
Landing at Edwards AFB

NOISE CONTOURS AROUND
RUNWAY 22
AT EDWARDS AFB

Tetra Tech, Inc.

4213 State Street, Suite 100
Santa Barbara, CA 93110-2847

TASK NO.	DATE	DRAWN BY	FILE NO.	FIGURE NO.
Q202-0701	11/6/02	RANDALL	Graphics:\Edwards AFB\ Re-Entry Corridor EA\ 3-16 NoiseContourMap.ai	3-16

and decrease gradually to either side. Because of the effects of the atmosphere, there is a distance to the side of the flight path beyond which the sonic booms are not expected to reach the ground. This distance is normally referred to as the lateral cut-off distance.

3.10.3.1 Measurements of Sonic Boom Impact on Structures

Many studies have been conducted on the effects of sonic booms on conventional (i.e., modern, inhabited) structures. Sonic boom overpressure, in units of psf, is the typical metric used to evaluate sonic boom impacts on structures.

The most common incidence of damage is to glass, plaster, and bric-a-brac. Table 3-13 presents the types of damage to structures that could potentially result from sonic booms. The actual occurrence of damage depends upon a number of variables; most important are the orientation of the object to the flight track, and the condition of the object.

Table 3-13
Possible Damage to Structures from Sonic Booms

Sonic Boom Peak Overpressure Nominal (psf)	Item Affected	Type of Damage
0.5 - 2	Cracks in plaster	Fine; extension of existing; more in ceilings; over door frames; between some plaster boards
	Cracks in glass	Rarely shattered; either partial or extension of existing.
	Damage to roof	Slippage of existing loose tiles/slates; sometimes new cracking of old slates at nail hole.
	Damage to outside walls	Existing cracks in stucco extended.
0.5 - 2	Bric-a-brac	Those carefully balanced or on edges can fall; fine glass, e.g., large goblets.
	Other	Dust falls in chimneys
2 - 4	Glass, plaster, roofs, ceilings	Failures show which would have been difficult to forecast in terms of their existing localized condition. Nominally in good condition.
4 - 10	Glass	Regular failures within a population of well-installed glass; industrial as well as domestic; green houses; ships; oil rigs.
	Plaster	Partial ceiling collapse of good plaster; complete collapse of very new, incompletely cured or very old plaster.
	Roofs	High probability rate of failure in nominally good slate, slurry-wash; some chance of failures in tiles on modern roofs; light roofs (bungalow) or large area can move bodily.
	Walls (outside)	Old, free standing walls in fairly good condition can collapse.
	Walls (inside)	"Party" walls known to move at 10 psf.
Greater than 10	Glass	Some good glass will fail regularly in response to sonic booms from the same direction. Glass with existing faults could shatter and fly. Large window frames move.
	Plaster	Most plaster affected.
	Ceilings	Plaster boards displaced by nail popping.
	Roofs	Most slate/slurry roofs affected, some badly; large roofs having good tile can be affected; some roofs bodily displaced causing gable-end and wall-plate cracks; Domestic chimneys - dislodgment if not in good condition.
	Walls	Internal party walls can move even if carrying fittings such as hand basins or taps; secondary damage due to water leakage.
	Bric-a-brac	Some nominally secure items can fall, e.g., large pictures; especially if fixed to party walls.

Note: psf- pounds per square foot
Source: U.S. Air Force, HSD-TR-89-01.

A 1973 FAA-sponsored study was conducted using a statistical analysis to determine the probability of glass breakage for various overpressures. If all flight paths are considered equally likely (that is, the aircraft could approach the structure from any direction) then the probability of breakage for good glass at various nominal peak overpressures is shown in Table 3-14 (FAA 1973).

Table 3-14
Probability of Glass Breakage Under Flight Path from Any Direction

Overpressures (psf)	Probability of Breakage
1	0.000001[a]
2	0.000023

Note: a - 1 pane in 1,000,000 panes.

If the aircraft were to approach from head-on or perpendicular to the plane of the window, which would be the worst condition, the probability would increase as shown in Table 3-15.

Table 3-15
Probability of Glass Breakage from Head-on or Perpendicular Flight Path

Overpressures (psf)	Probability of Breakage
1	0.000023[a]
2	0.000075
3	0.000300
4	0.001200
5	0.002300
6	0.004000

Note: a - 23 panes in 1,000,000 panes.

3.10.3.2 Measurements of Sonic Boom Impact on Human Annoyance

In 1977, at the request of the U.S. EPA, the National Academy of Science's Committee on Hearing, Bioacoustics and Biomechanics (CHABA) proposed guidelines for the uniform description and assessment of the various noise environments associated with various projects. In 1982, the U.S. EPA published *Guidelines for Noise Impact Analysis*, based on the CHABA Guidelines. According to CHABA Guidelines, the L_{eq} and DNL were selected as the appropriate descriptors for noise because they reliably correlate with health and welfare effects. From data on community social surveys, DNL has been found to correlate with community annoyance, as measured in terms of percentage of exposed persons who are "highly annoyed" (%HA) (Table 3-16).

Table 3-16
Relationship Between C-Weighted and A-Weighted Sound Levels
and Percent of the Population Annoyed

CDNL (C-weighted)	% Highly Annoyed	DNL (A-weighted)
48	2	50
52	4	55
57	8	60
61	14	65
65	23	70
69	35	75

Note: CDNL can be interpreted in terms of "equivalent annoyance" DNL.
Source: CHABA 1981

Exposure to sonic booms is typically measured as a CDNL, on a C-weighted scale, rather than as a DNL on an A-weighted scale. Correlation between DNL and CDNL has been established based on community reaction to impulsive sounds (CHABA 1981). The DoD has followed the recommendations of CHABA in describing high-intensity impulsive sounds, such as sonic booms and explosions, in terms of C-weighted sound exposure level. Table 3-16 shows the relationship between the percent of the population highly annoyed by sound levels expressed as DNL and CDNL.

A DNL of 65 dBA or lower is considered to be acceptable (Table 3-16); a DNL above 65 dBA but not exceeding 75 dBA is normally unacceptable unless some form of noise attenuation is provided; a DNL higher than 75 dBA is unacceptable. Daily exposure to sonic booms of CDNL of 61 dB or less is comparable to the DNL 65 dBA significance level for non-impulsive noise.

Sonic boom noise levels measured as a CSEL also provide a metric for potential impacts to humans over a short-term duration, rather than averaged over a 24-hour period. For example, CSEL values can be used to evaluate potential physiological startle responses and other short-term annoyance factors. Table 3-17 shows the relationship between sonic boom overpressure and CSELs and other noise metrics.

Table 3-17
Relationship Between Sonic Boom Overpressure in Pounds per Square Feet (psf) and Other Metrics (dB)

Peak Overpressure (psf)	CSEL (dB)	Peak SPL (dB)	SEL (dB)
0.2	85.4	113.6	75.9
0.5	94.0	121.6	84.5
1.0	100.4	127.6	90.9
2.0	106.9	133.6	97.4
3.0	110.7	137.1	101.2
4.0	113.4	139.6	103.9
5.0	115.5	141.6	106.0
6.0	117.2	143.1	107.7
8.0	119.9	145.6	110.4
10.0	121.9	147.6	112.4
12.0	123.6	149.2	114.1
14.0	125.1	150.5	115.6
18.0	127.4	152.7	117.9
22.0	129.3	154.4	119.8
26.0	130.9	155.9	121.4
30.0	132.2	157.1	122.7

3.10.3.3 Measurements of Sonic Boom Impact on Land Use Compatibility

In 1980, the Federal Interagency Committee on Urban Noise (FICUN) published guidelines for considering noise in land use planning (FICUN 1980). Federal agencies have adopted these guidelines as the standard when making recommendations to local communities on land use compatibility issues. Table 3-18 shows the types of land uses that would be appropriate based on a range of DNL values.

Again, a DNL of 65 dBA or lower is considered to be acceptable (Table 3-18); a DNL above 65 dBA but not exceeding 75 dBA is normally unacceptable unless some form of noise attenuation is provided; a

DNL higher than 75 dBA is unacceptable. Daily exposure to sonic booms of CDNL of 61 dB or less is comparable to the DNL 65 dBA significance level for non-impulsive noise and is normally considered compatible with most land uses.

3.11 PUBLIC/EMERGENCY SERVICES

Public/emergency services refers to the capability of ensuring protection of people and property.

3.11.1 On-Base Region

Public/emergency services at Edwards AFB ensure the protection of base personnel and property. The public/emergency service umbrella at Edwards AFB consists of the Fire Department, Security Forces, and the Medical Group.

3.11.1.1 Fire Protection/Prevention

Fire protection on base comprises personnel and equipment that are organized and trained to respond to a series of emergencies. The emergency response time of the Fire Protection Division is contingent upon the distance to the emergency site and the availability of personnel, support equipment, and supplies. All areas of the base are currently covered.

The proposed action would utilize Runway 22 or the Rogers Dry Lakebed for landing. This area is located near and serviced by Fire Station No. 1. This station is a 26,200-square-foot facility providing fire protection and emergency medical service as needed for the entire base. Vehicles assigned to this fire station include two engines; five Aircraft Rescue Fire Fighting vehicles; one rescue vehicle; a 5,000- and a 2,000-gallon water tender; and two airfield surveillance vehicles. A maximum of 35 firefighters are housed in this facility.

3.11.1.2 Security

Security forces provide general law enforcement on Edwards AFB. Law enforcement duties include traffic stops, domestic disputes, and police investigations. Security forces (police) on base comprise personnel and equipment organized and trained to respond to a series of emergencies, as well as to provide a daily security presence. Security programs provide the means to counter threats during peacetime, mobilization, or wartime.

3.11.1.3 Medical Services

Medical services on-base comprise personnel and equipment that are organized and trained to respond to a series of emergencies. Air Force Instruction 41-106, *Medical Readiness Planning and Training*, establishes procedures for medical readiness, planning, and training during peacetime and wartime operations.

3.11.2 Off-Base Region

Public/emergency services within the Alternative A and B corridors include all state and local fire protection services, security forces, and medical services utilized by the general public during accidents, disasters, or events commonly requiring such public/emergency services.

Table 3-18
Land Use Compatibility

Land Use	Yearly Day-Night Average Sound Level (DNL) in Decibels					
	Below 65	65–70	70–75	75–80	80–85	Over 85
Residential						
Residential, other than mobile homes and transient lodgings	Y	N[1]	N[1]	N	N	N
Mobile home parks	Y	N	N	N	N	N
Transient lodgings	Y	N[1]	N[1]	N[1]	N	N
Public Use						
Schools	Y	N[1]	N[1]	N	N	N
Hospitals and nursing homes	Y	25	30	N	N	N
Churches, auditoria, and concert halls	Y	25	30	N	N	N
Government services	Y	Y	25	30	N	N
Transportation	Y	Y	Y[2]	Y[3]	Y[4]	Y[4]
Parking	Y	Y	Y[2]	Y[3]	Y[4]	N
Commercial Use						
Offices, business and professional	Y	Y	25	30	N	N
Wholesale and retail—building materials, hardware, and farm equipment	Y	Y	Y[2]	Y[3]	Y[4]	N
Retail trade—general	Y	Y	25	30	N	N
Utilities	Y	Y	Y[2]	Y[3]	Y[4]	N
Communication	Y	Y	25	30	N	N
Manufacturing and Production						
Manufacturing, general	Y	Y	Y[2]	Y[3]	Y[4]	N
Photographic and optical	Y	Y	25	30	N	N
Agriculture (except livestock) and forestry	Y	Y[6]	Y[7]	Y[8]	Y[8]	Y[8]
Livestock farming and breeding	Y	Y[6]	Y[7]	N	N	N
Mining and fishing, resource production and extraction	Y	Y	Y	Y	Y	Y
Recreational						
Outdoor sports arenas and spectator sports	Y	Y[5]	Y[5]	N	N	N
Outdoor music shells, amphitheaters	Y	N	N	N	N	N
Nature exhibits and zoos	Y	Y	N	N	N	N
Amusements, parks, resorts, and camps	Y	Y	Y	N	N	N
Golf courses, riding stables, and water recreation	Y	Y	25	30	N	N

Notes:

Numbers in parentheses refer to notes.

* - The designations contained in this table do not constitute a federal determination that any use of land covered by the program is acceptable or unacceptable under federal, state, or local law. The responsibility for determining the acceptable and permissible land uses and the relationship between specific properties and specific noise contours rests with the local authorities. FAA determinations under Part 150 are not intended to substitute federally determined land uses for those determined to be appropriate by local authorities in response to locally determined needs and values in achieving noise-compatible land uses.

Y (YES) - Land Use and related structures compatible without restrictions.

N (No) - Land Use and related structures are not compatible and should be prohibited.

NLR - Noise Level Reduction (outdoor to indoor) to be achieved through incorporation of noise attenuation into the design and construction of the structure.

25, 30, or 35 - Land Use and related structures generally compatible; measures to achieve NLR of 25, 30, or 35 dB must be incorporated into design and construction of structures.

1 - Where the community determines that residential or school uses must be allowed, measures to achieve outdoor-to-indoor Noise Level Reduction (NLR) of at least 25 dB and 30 dB should be incorporated into building codes and be considered in individual approvals. Normal residential construction can be expected to provide an NLR of 20 dB; thus the reduction requirements are often stated as 5, 10, or 15 dB over standard construction and normally assume mechanical ventilation and closed windows year-round. However, the use of NLR criteria will not eliminate outdoor noise problems.

2 - Measures to achieve NLR 25 dB must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise sensitive areas, or where the normal noise level is low.

3 - Measures to achieve NLR 30 dB must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise-sensitive areas, or where the normal noise level is low.

4 - Measures to achieve NLR 35 dB must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise-sensitive areas, or where the normal noise level is low.

5 - Land-use compatible provided special sound reinforcement systems are installed.

6 - Residential buildings require an NLR of 25.

7 - Residential buildings require an NLR of 30.

8 - Residential buildings not permitted.

Source: 14 CFR Part 150

3.12 SAFETY

Safety is defined as the protection of workers and the public from hazards. The total accident spectrum encompasses not only injury to personnel, but also damage or destruction of property or products. For worker safety, the boundary of the immediate work area defines the ROI. For public safety, a much larger area must be considered. This area varies depending upon the nature of the operation, but may extend for miles beyond the source of the hazard.

Potential health and safety issues on Edwards AFB include radiological, biological, chemical, and physical hazards, as well as weapons, flight, ground, range, and test [systems] safety.

The DFRC's institutional safety program is intended to minimize accidental injury, illness, and loss of property. DFRC's Safety Office is responsible for monitoring the safety programs through a system of inspections, surveys, audits, and follow-up investigations. Elements of the safety program include accident and injury prevention and reporting, fire prevention and protection, emergency preparedness, and hazardous material and waste management. A DFRC Emergency Response Plan is in place to address emergencies such as earthquakes, aircraft accidents, fires and explosions, bomb threats, civil disturbances, nuclear emergencies, and toxic vapor releases or chemical spills. A NASA-wide safety reporting system encourages employees to report their concerns about workplace safety.

The DFRC's occupational health program is intended to recognize, evaluate, and control workplace factors or stresses that may cause sickness, impaired health, or significant discomfort to employees. To protect DFRC personnel from noise hazards, hearing protection is used if personnel are exposed to noise levels exceeding 85 dBA. The program identifies and quantifies worker exposure to hazardous chemicals, noise, and radiation. Through DFRC's Hazardous Communication Program, employees are educated regarding proper chemical management principles and procedures.

3.12.1 Range Safety

The national range system, established by Public Law (PL) 81-60, was originally sited based on two primary concerns: location and public safety. Thus, range safety, in the context of national range activities, is rooted in PL 81-60 and Department of Defense Directive 3200.11*, Use Management*, and *Operation of Department of Defense Major Range and Test Facilities*; both provide the framework under which the national ranges operate and provide services to range users. To provide for the public safety, the ranges, using a Range Safety Program, ensure that the launch and flight of launch vehicles present no greater risk to the general public than that imposed by overflight of conventional aircraft.

It is the policy of the Edwards AFB Range to ensure that the risk to the public, military personnel, government civilian workforce, contractors, and to national resources is minimized to the greatest degree possible. This policy is implemented by using risk management in the areas of public safety, launch area safety, and landing area safety. Range users are required by Edwards AFB to demonstrate, through risk modeling, that the lowest possible risk is achieved, consistent with mission requirements and AFFTC launch risk guidance. The AFFTC Chief of Safety has responsibility for approving the proposed flight plan, flight termination system(s), and flight safety criteria. The AFFTC Commander has final authority and responsibility for the safety of the proposed action. The Range Commander may deviate from these mission criteria based on geography, weather, and national need; however, the basic standard is no more risk than that voluntarily accepted by the general public in normal day-to-day activities (NASA 1997).

Health and safety issues related to aircraft operations (both routine and emergency management) involving ground personnel working near operating aircraft during taxiing and inspection activities, aircrews using runways (lakebed and non-lakebed surfaces), and personnel present during emergency operations, aircraft malfunction, or other mishap are specifically addressed in Air Force Flight Test Center Instruction (AFFTCI) 11-1*, Air Operations,* and AFFTCI 11-2*, Ground Operations*. These instructions address in-flight operations, flight preparation, and ground procedures directly related to the safety of personnel on the ground, as well as emergency procedures for the protection of all personnel at Edwards AFB.

A fundamental requirement of the Edwards AFB Flight Safety Program is that each unit conducting or supporting flight operations has a flight safety program as well as a Midair Collision Avoidance Program.

A QRA was prepared to provide defensible evidence to support the orbital reentry corridors identified under Alternatives A and B (Appendix A). This analysis addressed the risks to persons and property resulting from use of these reentry corridors. To determine the risk to the ground populations, a model of population sheltering was developed based on census data from the western United States and Canada. To calculate aircraft risk, FAA data were used to create a model of aircraft density. The risk calculation allowed for uncertainties in fragment description, season (as it affects both the atmosphere and sheltering), trajectory information, and vehicle failure mode.

The computed risk was compared with two standards: the Range Commanders Council (RCC), which requires an expectation of fatality, E_F, less than 30×10^{-6} (30 fatalities per million missions) and the Range Safety Requirements of the Eastern and Western Ranges, which require an expectation of casualty, E_c, of 30×10^{-6} (30 casualties per million missions). Following these standards, three corridors or trajectories were recommended for missions with failure probabilities less than one percent. These corridors are a western corridor with azimuth from 250 to 290 degrees, which was selected as Alternative A; a northwestern corridor with azimuth from 325 to 337 degrees, which was selected as Alternate B; and a polar orbit corridor with azimuth from 350 to 020 degrees, which was not selected as an alternative because a polar orbit reentry corridor would not normally be considered as a primary reentry corridor for flight test of an experimental unmanned LEV. The probability of aircraft impact for each corridor is less than the RCC standard of 1×10^{-7} (1 impact in 10 million missions) and the Eastern and Western Range common practice of 1×10^{-8} (1 impact in 100 million missions).

3.12.2 Exposure Hazards

Non-ionizing Electromagnetic Radiation

Non-ionizing electromagnetic radiation (EMR) comes from two major sources on base: radio frequency emitters (i.e., radar, radar-jamming transmitters, and radio communication equipment), which are regulated in accordance with the Air Force Occupational Safety and Health (AFOSH) Standard 48-9, *Radio Frequency Radiation Safety Program*; and laser emitters (lasers), which are regulated by AFOSH Standard 48-10*, Laser Radiation Protection Program*. Sources of EMR at Edwards AFB exist throughout flightline areas, and include fixed location radar, airfield management equipment, and aircraft equipment/instrumentation. Electromagnetic radiation can cause thermal and photochemical injuries to humans, particularly to the eyes and skin. Standards and practices are in place to shield and isolate workers from operational hazards surrounding existing EMR sources.

The Bioenvironmental Engineering Office periodically visits and evaluates the operations of all known AFFTC industrial radiation users as a part of the Industrial Hygiene Surveillance Program. This office also annually verifies the list of on-base radio frequency radiation emitters. Any proposed use of emitters is evaluated using a preliminary radiation hazard analysis. Using a permissible exposure limit (PEL), a proper hazard analysis is accomplished. This PEL is expressed in terms of safe distance limits from the emitting source. Compliance with these limits is required as a Standard Operating Procedure (AFFTC 1997d).

Lasers

There are many laser-based systems used in Edwards AFB operations, most of which are used on aircraft during flight operations as target-range finders and target designators. Laser weapons are used for test and training activities at approved locations on Edwards AFB under scheduled and controlled conditions (i.e., Integrated Facility for Avionics Testing, Benefield Anechoic Facility).

Lasers produce narrow beams of light that may or may not be in the range of light visible to humans. Edwards AFB tests about four types of American National Standards Institute Class 3 lasers, which are mainly used for range operations (Cogan 1995).

Explosives and Propellants

Explosives and propellants are used and stored in a number of locations throughout Edwards AFB. An inhabited building separation distance (or clear zone) has been established around each of the existing explosives and/or propellant use/storage locations. The size of the clear zone varies based on the quantity and type of explosive used, or propellant stored. Clear zones ensure the safety of all personnel in the area from the potential overpressure hazard associated with use and storage of these materials.

3.13 SOCIOECONOMICS

Socioeconomic resources are the economic, demographic, and social assets of a community. Key elements include fiscal growth, population, labor force and employment, housing stock and demand, and school enrollment.

3.13.1 Edwards AFB

Edwards AFB makes a substantial contribution to the economic status of the surrounding communities within Antelope Valley of California.

The Antelope Valley has a labor force of approximately 161,031 persons with an unemployment rate of 13.6 percent. The labor force is employed in a variety of industries including services, manufacturing, construction/mining, retail, government, and agriculture. The military labor force comprised two percent and the government labor force comprised six percent of those employed in the Antelope Valley in 1997 (Alfred Gobar Associates 1997). As of March 31, 1999, Edwards AFB employed approximately 10,920 military, civilians, and contractor personnel.

Edwards AFB provides permanent party housing for military members in the form of dormitories, military family housing, and mobile home park spaces. Edwards AFB has an approximate total of 1,741 housing units with an occupancy rate goal of 98 percent. The number of housing units fluctuates due to the demolition of older units and construction of new units. The number of units ranges from 1,640 to 1,777. Edwards AFB also maintains a 188-space mobile home park for privately owned mobile homes. Personnel with families and unaccompanied members are allowed to reside in the park (MARCOA Publishing, Inc. 1998).

Unaccompanied enlisted members and designated key and essential personnel are required to live on base. Edwards AFB has two- and three-story dormitories, each housing from 32 to 84 members in single and double rooms. A new complex with single rooms has recently been opened. Transient quarters are available through the Billeting Office.

Edwards AFB has three elementary schools and one junior/senior high school, both under the jurisdiction of the Muroc Unified School District. The 1998 to 1999 school year enrollment for these schools was 385, 346, and 457, respectively. The 1998 to 1999 school year enrollment for Desert Junior/Senior High School was 626.

Several additional school districts exist within the Antelope Valley. For the 1998 to 1999 school year, total enrollment in these school districts was 128,029 (California Department of Education). Numerous private schools also exist within this region.

In fiscal year 1998, Edwards AFB expended $3,186,230 for training and education of active duty personnel and civilians. Impact Aid provided by the Department of Education to school districts that are associated with Edwards AFB was $4,631,541 for fiscal year 1998. This aid is provided to schools that have children who reside on base or whose parents work on base, or both. These parents may be active duty military or civilians (Levell 1999).

3.14 WATER RESOURCES

Water resources include surface water and groundwater quantity and quality.

3.14.1 On-Base Region

3.14.1.1 Water Quantity and Source

Sources of water on Edwards AFB include groundwater, AVEK Water Agency water, and storm water. Jurisdictional waters of the United States do not occur within Edwards Air Force Base (USACOE 1996).

The AFFTC purchases potable water from the AVEK Water Agency through a water distribution system located in Boron. Groundwater has been an important source of water for the Antelope Valley since development began there in the late 1800s, and for the base since 1947. In recent years of rapid urban growth and drought, between 50 and 90 percent of all water demands in the Valley were satisfied by groundwater. Groundwater pumping and irrigation of crops began to decrease when water levels declined. Groundwater depth has declined approximately 90 feet since 1947 (AFFTC 1999). Edwards AFB uses 12 groundwater wells, 10 of which are reserved for drinking water purposes. The 10 potable water wells have a maximum combined production capability of 15.6 million gallons per day.

3.14.1.2 Water Quality

The U.S. EPA's Office of Water establishes the groundwater and drinking water quality standards found in the National Primary Drinking Water Regulations (or primary standards) that are legally enforceable and apply to public water systems. Edwards AFB must also conform to the standards for clean water set by the Cal EPA. These standards are administered locally by the Lahontan Regional Water Quality Control Board. Primary standards protect drinking water quality by limiting the levels of specific contaminants that can adversely affect public health and are known or anticipated to occur in public water systems. The Bioenvironmental Engineering Office monitors base groundwater quality, and compliance with drinking water standards.

3.14.1.3 Flood Potential

Edwards AFB is situated at the bottom of the Antelope Valley Watershed Basin, roughly a 2,400 square mile watershed with no outlet. As such, stormwater runoff for the entire watershed is directed toward three large playa lakebeds: Rogers, Rosamond, and Buckhorn Dry Lakes. Playas are expansive, ancient dry lakes that fill with water during seasonal rainfall periods. Water may be retained in these playas for several months due to mostly impermeable soils that contain high levels of solute, alkalinity, salinity, sodium, and total dissolved solids. Any water reaching these lakebeds is trapped, pending evaporation (USGS 1998).

In general, drainage tends to flow toward the nearest dry lakebed. Rosamond and Buckhorn Dry Lakes, in turn, drain toward Rogers Dry Lake (AFFTC 1993). Water level elevations (above msl) for Rosamond Dry Lake during flood conditions are described in Table 3-19 (USACOE 1995).

Table 3-19
Water Levels for Rosamond Dry Lake Flooding Events

Flood Level	Lake Elevation (feet)
50-year	2,280.9
100-year	2,282.2
200-year	2,283.4

Despite the apparent potential for the formation of a sizable lake, the playa lakebeds remain dry most of the time due to arid climate conditions. The average annual rainfall at the base is approximately 5 inches and the maximum recorded 1-year rainfall is 15.5 inches, which occurred in 1983. The average annual evaporation, as measured by a nearby Mojave pan evaporation gauge from 1939 to 1959, is 11.4 inches.

The Mojave Creek Floodplain is a well-defined drainage that runs southeast along the north and east of the residential area of Main Base along Lancaster Boulevard and crosses Rosamond Boulevard where it runs southward just west of South Base and empties into Rogers Dry Lake. Mojave Creek is dry for most of the year, but periodic flooding does occur during above-normal rainfall periods (AFFTC 1993).

In 1993, a flood study of the base was conducted to determine floodplain constraints (AFFTC 1993). Flood-prone areas that were identified include Rogers Dry Lake, Rosamond Dry Lake, and Mojave Creek, which empties into Rogers Dry Lake. There are other flood-prone areas on base in the residential area where water is trapped and no channels are present to divert heavy storm water runoff.

The AFFTC 1993 flood study estimated a flood-of-record inundation elevation to be used for planning purposes and performed a risk of flooding analysis of existing base facilities near Rogers Dry Lake. This level represents the maximum water surface elevation that would occur during a flood of reasonably high return interval (e.g., 50 years, 100 years). The level of flooding that occurred in 1943 was estimated to be the flood-of-record level. Most development on Edwards AFB is above this estimated flood-of-level of 2,277.4 feet. However, a relatively high flooding in 1993 remained more than 3 feet below the estimated flood-of-record level (AFFTC 1993).

3.14.2 Off-Base Region

3.14.2.1 Alternative A (Western Approach)

The land beneath the Alternative A corridor contains 19 watersheds. Table 3-20 provides comparisons of land acreage and waterway mileage within each watershed (California Rivers Assessment 1997). Table 3-21 provides a list of rivers and creeks within the area below the Alternative A corridor, five of which hold Wild and Scenic River status.

Major lakes within Alternative A include Buena Vista Lake in Kern County; Pyramid Lake in Los Angeles County; Lake Casitas in Ventura County; Gibraltar Reservoir and Lake Cachuma in Santa Barbara County; Twitchell Reservoir, Lopez Lake, Santa Margarita Lake, and Lake Nacimiento in San Luis Obispo County; and Lake San Antonio in Monterey County.

3.14.2.2 Alternative B (Northwestern Approach)

Alternative B contains 98 watersheds throughout California, Nevada, and Oregon (California Rivers Assessment 1997) (Table 3-22). Table 3-23 provides a list of rivers and creeks within Alternative B, 20 of which hold Wild and Scenic River status.

The area below the Alternative B corridor contains hundreds of lakes and reservoirs, including the two deepest lakes in the United States: Crater Lake (1,932 feet) in Oregon and Lake Tahoe (1,645 feet) on the California/Nevada border. Other major lakes within 200 miles of Edwards AFB include Isabella Lake in Kern County; Lake Success and Lake Kaweah in Tulare County; Hume Lake, Wishon Reservoir, Courtright Reservoir, Florence Lake, Lake Thomas A. Edison, Huntington Lake, Shaver Lake, Mammoth Pool Reservoir, and Pine Flat Reservoir in Fresno County.

Table 3-20
Watersheds Under the Alternative A Corridor

Watershed	Acres	Miles of Naturally Occurring Waterways
Alisal-Elkhorn Sloughs	155,539.57	346.09
Antelope-Fremont	2,168,077.64	4,352.77
Calleguas	242,578.07	483.15
Carmel	199,570.32	464
Carrizo	283,322.39	522.66
Central Coast	673,977.61	1,398.65
Cuyama	732,147.42	2,007.67
Estrella	606,872.66	1,410.81
Middle Kern-Upper Tehachapi	851,259.50	2,169.58
Pajaro	838,326.29	1,970.06
Salinas	2,099,440.67	4872.39
San Antonio	138,628.04	278.98
Santa Barbara Coastal	240,719.88	632.83
Santa Clara	1,032,302.26	2,623.92
Santa Maria	453,776.91	1,082.58
Santa Ynez	574,885.56	1,556.18
Tulare-Buena Vista Lakes	5,453,232.60	4,905.87
Upper Los Gatos	490,036.37	1,272.01
Ventura	173,629.76	461.12

Source: California Environmental Resources Evaluation System 2001.

Table 3-21
Rivers and Creeks Under the Alternative A Corridor

River or Creek	County	Special Designation
Big Sur	Monterey	Wild & Scenic River
Caliente	Kern	
Carmel	Monterey	
Cottonwood	Kern	
Cuyama	Santa Barbara, San Luis Obispo	
Estrella	San Luis Obispo	
Jalama	Sant Barbara	
Kern	Kern, Tulare	Wild & Scenic River
Kings	Kings, Tulare	Wild & Scenic River
Nacimiento	Monterey	
Poso	Kern, Tulare	
Salinas	Monterey, San Luis Obispo	
San Antonio	Santa Barbara	
San Juan	San Luis Obispo	
Santa Clara	Ventura, Los Angeles	
Santa Maria	Santa Barbara	
Santa Ynez	Santa Barbara	
Sespe	Santa Barbara	Wild & Scenic River
Sisquoc	Santa Barbara	Wild & Scenic River
Tule	Kings, Tulare	
Ventura	Santa Barbara, Ventura	
White	Tulare	

Source: National Park Service 2001.

Table 3-22
Watersheds Under the Alternative B Corridor

Watershed	Acres	Miles of Naturally Occurring Waterways
Applegate	58,273.59	91.22
Butte	380,756.39	212.94
Chetco	11,727.37	21.89
Cottonwood Headwaters	440,102.40	808.54
Crowley Lake	1,190,498.15	2,020.24
East Branch North Fork Feather	656,964.77	1,318.22
East Walker	324,506.55	498.61
Honcut Headwaters	117,095.75	315.69
Honey-Eagle Lakes	1,418,877.85	1,713.90
Illinois	37,845.84	70.71
Indian Wells-Searles Valleys	1,290,877.58	2,136.03
Lake Tahoe	238,809.80	250.04
Lost	1,088,863.45	676.05
Lower American	180,706.70	379.46
Lower Butte	367,635.38	661.64
Lower Cottonwood	162,371.88	352.87
Lower Feather	378,465.77	530.78
Lower Klamath	979815.75	1780.41
Lower Pit	1,708,590.25	1,598.99
Madaline Plains	513,540.52	424.29
McCloud	435,130.75	618.26
Middle Fork Feather	871,778.68	1,752.05
Mill	111,592.83	243.01
Mill-Big Chico	570,625.56	1,020.40
North Fork American	647,154.90	1317.6
North Fork Feather	80,578.51	1,338.69
Owens Lake	878,294.71	1,059.99
Sacramento Headwaters	412,283.88	560.84
Sacramento-Lower Cow-Lower Clear	245,461.73	552.93
Sacramento-Lower Thomes	675,361.37	1,820.32
Sacramento-Upper Clear	201,774.45	333.8
Salmon	480,864.01	864.5
Scott	520,968.34	878.83
Shasta	508,734.42	603
Smith	452,091.69	842.37
South Fork American	543,219.70	1,143.41
South Fork Kern	627,757.55	1,088.98
Trinity	1,304,178.97	2,234.93
Truckee	274,372.43	497.93

Table 3-22, Page 1 of 2

Table 3-22
Watersheds Under the Alternative B Corridor (Continued)

Watershed	Acres	Miles of Naturally Occurring Waterways
Upper Bear	259,032.46	564.76
Upper Butte	130,602.23	296.44
Upper Calaveras	250,977.00	780.80
Upper Carson	289,996.56	586.36
Upper Chowchilla-Upper Fresno	620883.23	1196.31
Upper Coon-Upper Auburn	69,919.42	154.96
Upper Cosumnes	421,656.38	1,017.54
Upper Cow-Battle	531,329.25	861.17
Upper Deer-Upper White	227,761.95	391.62
Upper Dry	92,993.61	223.1
Upper Kaweah	574,754.60	976.08
Upper Kern	700,014.53	1,138.41
Upper King	988,565.56	16,272.92
Upper Klamath	544,215.51	880.36
Upper Merced	703,115.64	1,305.26
Upper Mokelumne	519,643.89	1,308.44
Upper Pit	1,702,444.87	3,097.22
Upper Poso	168,796.48	308.17
Upper San Joaquin	1,090,990.98	1714.35
Upper Stanislaus	640,372.01	1,659.51
Upper Tule	285,958.95	509.82
Upper Tuolumne	1,033,493.28	1,944.37
Upper Yuba	842,717.25	1,725.24
West Walker	261,434.27	424.98

Table 3-22, Page 2 of 2

Source: California Environmental Resources Evaluation System 2001

Table 3-23
Rivers and Creeks Under the Alternative B Corridor

CALIFORNIA

River or Creek	County	Special Designation
American River	El Dorado, Placer	Wild & Scenic
Antelope Creek	Siskiyou	
Antelope Creek	Tehama	
Applegate River	Siskiyou	
Auburn Ravine	Placer	
Battle Creek	Shasta	
Bear Creek	Nevada	
Bear River	Placer	
Butte Creek	Siskiyou	
Butte Creek	Butte	
Caliente Creek	Kern	
Carson River	Alpine, Tuolumne	
Chowchilla River	Modera	
Clavey River	Tuolumne	
Clear Creek	El Dorado	
Clear Creek	Shasta	
Cosumnes River	Amador, El Dorado	
Cottonwood Creek	Kern	
Cottonwood Creek	Shasta, Tehama	
Cow Creek	Shasta	
Coyote Creek	Calaveras	
Deer Creek	Tehama	
Dry Creek	Fresno, Mono, Tuolumne	
Dry Creek	Nevada	
Elder Creek	Tehama	
Feather River	Butte, Plumas, Sutter, Tehama, Yuba	Wild & Scenic
Fresno River	Modera	
Grindstone Creek	Glenn	
Illinois Creek	Del Norte	
Kern River	Kern, Tulare	Wild & Scenic
Keweah River	Tulare	
Kings River	Fresno	Wild & Scenic
Klamath River	Del Norte, Humboldt, Siskiyou	Wild & Scenic
Lost River	Modoc, Siskiyou	
McCloud River	Shasta	
Merced River	Mariposa, Modera	
Mill Creek	Fresno	
Mill Creek	Tehama	
Mill Creek	Tuolumne	

Table 3-23, Page 1 of 4

Table 3-23
Rivers and Creeks Under the Alternative B Corridor (Continued)

CALIFORNIA (continued)		
Mokelumne River	Almador, Alpine, Calaveras	
Owens River	Tuolumne	
Pit River	Lassen, Modoc, Shasta	
Poso River	Kern	
Rubicon River	El Dorado, Placer	
Sacramento River	Butte, Glenn, Placer, Shasta, Siskiyou, Tehama	
Salmon River	Siskiyou	Wild & Scenic
San Antonio Creek	Calaveras	
San Joaquin River	Fresno, Modera	
Scott River	Siskiyou	
Shasta River	Shasta, Siskiyou	
Shonecut Creek	Butte, Yuba	
Smith River	Del Norte	Wild & Scenic
Stanislaus River	Tuolumne	
Stony Creek	Glenn	
Susan River	Lassen	
Thomes Creek	Tehama	
Trinity River	Shasta, Trinity	Wild & Scenic
Truckee River	Nevada, Placer, Sierra	
Tule River	Tulare	
Tuolumne River	Tuolumne	Wild & Scenic
Upper Truckee River	Alpine, El Dorado, Tuolumne	
W Walker River	Tuolumne	
White River	Tulare	
Wolf Creek	Nevada	
Yuba River	Nevada, Sierra, Yuba	

Table 3-23, Page 2 of 4

Table 3-23
Rivers and Creeks Under the Alternative B Corridor (Continued)

OREGON		
River or Creek	**County**	
Abiqua Creek	Marion	
Alsea River	Benton, Lincoln	
Applegate River	Jackson, Josephine	
Bilyeu Creek	Linn	
Boulder Creek	Douglas	
Briggs Creek	Josephine	
Calapooia River	Linn	
Chetco River	Curry	Wild & Scenic
Clearwater River	Douglas	
Coal Creek	Douglas, Lane	
Columbia River	Clatsop, Columbia, Multinomah	
Coos River	Coos	
Copeland Creek	Douglas	
Coquille River	Coos, Curry, Douglas, Josephine	
Cow Creek	Douglas	
Crabtree Creek	Linn	
Crescent Creek	Klamath	Wild & Scenic
Dead Indian Creek	Jackson	
Deer Creek	Josephine	
Drift Creek	Lincoln	
Drift Creek	Marion	
Evans Creek	Jackson	
Floras Creek	Curry	
Grave Creek	Josephine	
Illinois River	Josephine	Wild & Scenic
Jackson Creek	Douglas	
Keene Creek	Jackson	
Klamath River	Klamath	Wild & Scenic
Klaskanine River	Clatsop	
Lawson Creek	Curry	
Little Deschutes River	Klamath	Wild & Scenic
Little Fall Creek	Lane	
Lost Creek	Lane	
Lost River	Klamath	
Lowell Creek	Lane	
McKenzie River	Lane	Wild & Scenic
Meryl Creek	Klamath	
Millter Creek	Klamath	

Table 3-23, Page 3 of 4

Table 3-23
Rivers and Creeks Under the Alternative B Corridor (Continued)

OREGON (continued)		
Mohawk River	Lane	
Molalla River	Clackamas	
Nehalem River	Clatsop, Tillamook	
Pleasant Creek	Jackson	
Roaring River	Linn	Wild & Scenic
Rock Creek	Douglas	
Rock Creek	Clatsop	
Rogue River	Curry, Jackson, Josephine	Wild & Scenic
Row River	Lane	
Salmon Creek	Lane	
Sand Creek	Coos	
Santium River	Linn, Marion	
Sharps Creek	Lane	
Shasta Costa Creek	Curry	
Silver Creek	Josephine	
Silver Creek	Marion	
Siuslaw River	Lane	
Smith River	Curry, Douglas	Wild & Scenic
Spencer Creek	Klamath	
Sprague River	Klamath	Wild & Scenic
Staley Creek	Douglas, Lane	
Steamboat Creek	Douglas, Lane	
Thomas Creek	Linn	
Trask River	Tillamook	
Umpqua River	Douglas	
Wiley Creek	Linn	
Willamette River	Benton, Clackamas, Columbia, Klamath, Lane, Linn, Marion, Multinomah, Polk, Yamhill	Wild & Scenic
Wilson River	Tillamook	
Wolf Creek	Josephine	
Wolf Creek	Lane	
Yaquina River	Lincoln	

Table 3-23, Page 4 of 4
Source: National Park Service 2001.

4.0 ENVIRONMENTAL CONSEQUENCES

This chapter discusses the potential environmental consequences or impacts associated with Alternatives A, B, and C. Changes to the natural and human environment that could result from Alternatives A, B, and C were evaluated relative to the existing environmental conditions described within Chapter 3.0. The first paragraph or discussion under each of the 14 environmental disciplines presents a description of what would constitute a significant impact for each discipline.

This EA only addresses the reentry and landing phases of the Orbital Reentry Corridor Program. Analysis of other phases (vehicle fabrication, launch, refurbishment, etc.) will be the responsibility of the intended test vehicle program office; separate environmental documentation would be required under these phases of the program.

In general, potential impacts associated with the proposed project fall under one of two categories: (1) impacts associated with potential failure of the unmanned LEV and a crash, or (2) impacts associated with normal operation of the reentry and landing phases of the Orbital Reentry Corridor Program. The unmanned LEV is assumed to weigh 25,000 pounds during reentry, and to be 30 feet long and 15.5 feet wide. If the unmanned LEV were to crash, for the purpose of this document, it is assumed that it could either crash intact or break into its seven components, which consist of two vertical fins, two rudders, two body flaps, and the core body, according to the QRA (Appendix A). Normal operation of the reentry and landing phases of the Orbital Reentry Corridor Program includes vertical and horizontal maneuvering of the unmanned LEV during reentry and landing the vehicle on Runway 22 or on Rogers Dry Lakebed at Edwards AFB.

4.1 AIR QUALITY

Air quality impacts include both policy and physical air quality changes. Air quality impacts are typically judged to be significant if the action being evaluated causes or contributes to a violation of state or federal ambient air quality standards; increases exposure of people to air pollution in concentrations in violation of ambient air quality standards; causes pollutant or pollutant precursor emissions in excess of local air quality management agency impact significance thresholds; or violates federal, state, or local emission limitations for specific pollutants or emission sources.

Kern County is in attainment or unclassified for most air quality standards with the exception of serious non-attainment status for the federal and state one-hour ozone standards and non-attainment status for the state PM_{10} standard in one portion of the county, outside the on-base region. The proposed project would have a significant impact on regional air quality if the estimate of total long-term and short-term, direct and indirect project emissions exceeds current air quality standards and/or KCAPCD thresholds within the MDAB.

This evaluation analyzes the maximum emission impacts based on 12 flights per year.

4.1.1 Alternative A (Western Approach)

4.1.1.1 On-Base Region

Sources of emissions generated under Alternative A include emissions (1) from privately owned vehicles of current on- or off-base Air Force or contractor personnel required for temporary duty for 5 days per landing, (2) one landing and takeoff (LTO) each for an F-15 and F-16 escort aircraft during unmanned LEV reentry, (3) C-130H air transport aircraft relocating the unmanned LEV to and from Edwards AFB, and (4) aerospace ground equipment (AGE) and (5) ground support equipment (GSE) for unmanned LEV ground transport (consisting of a lifting crane vehicle, a flatbed truck, and four pick-up trucks). Since there would be no new construction or specialty equipment required, the actual emissions resulting from and assessed under Alternative A primarily would occur from privately owned vehicles, escort and transport aircraft, AGE, and GSE.

Escort aircraft flights are anticipated to be 1 hour in duration with approximately 25 percent of that time spent below 3,000 feet AGL. Emissions from escort and air transport aircraft LTOs and flights were calculated using engine emission factors specific to each potential engine-operating mode as obtained from the Air Force Engineering and Services Center, *Aircraft Engine Emissions Estimator* (Air Force Engineering and Services Center 1985). Engine emission factors were multiplied by (1) the total number of operations expected to occur per unmanned LEV landing, (2) the number of engines operating during a particular operation, (3) the time duration in each engine mode for the particular operation, and (4) the estimated amount of time the flights are expected to be below 3,000 feet AGL.

The AGE/GSE emissions were calculated using emission factors obtained from *AP-42: Compilation of Emission Air Pollutant Factors* (U.S. EPA 1991) and from equipment manufacturers. AGE emissions were calculated as the summation of individual aircraft LTOs multiplied by the aircraft-specific emission factors assuming 8 hours on the ground after recovery. GSE emission calculations were performed utilizing duration of activity or miles driven and vehicle engine emissions for the given size ground transport vehicles.

The vehicle emissions from current on- or off-base Air Force, NASA, or contractor personnel required for temporary duty for 5 days per landing are not evaluated in this analysis because they are exempt under 40 CFR 51.853(c)(2)(vii) and (x). The routine, recurring transportation of personnel, or future activities conducted are similar in scope and operation to those currently being conducted at existing facilities. This will result in no emissions increase or emissions that are clearly *de minimis*. Therefore, those actions (transportation of personnel in this case) are exempt.

The total project emissions for both Alternatives A and B for a typical unmanned LEV landing are summarized in Table 4-1. A detailed summary showing the emissions calculations from each activity is provided in Appendix B.

An air conformity applicability analysis was conducted for the proposed project. Based upon the serious ozone non-attainment status of the Kern County portion of Edwards AFB, the proposed project would conform to the most recent EPA-approved SIP if the total direct and indirect emissions remain below *de minimis* thresholds established in the U.S. EPA's conformity rule for general federal actions. The *de minimis* emissions thresholds are 50 tons per year of NO_x and VOCs. While Kern County is in attainment of the NAAQS for PM_{10}, the MDAB (including the valley portion of Kern County) is in non-attainment for the PM_{10} state standard. The *de minimis* emissions threshold for PM_{10} is 100 tons per year.

Emissions subject to conformity applicability analysis from aircraft LTOs and flights, and AGE/GSE, sources are summarized in Table 4-1. Emissions from aircraft operating in airspace above 3,000 feet AGL were not included because these emissions would (1) be released above the mixing height and effectively blocked from dispersion to the surface or (2) be released from such a height and over such a vast area that ground-level concentrations resulting from downward dispersion would be negligible.

The area that would be affected by the emissions shown in Table 4-1 is the immediate area around Edwards AFB, situated in the MDAB portion of Kern County. The Valley portion of Kern County,

Table 4-1
Conformity Applicability for Total Emissions Sources Associated with the Unmanned LEV Landing Program at Edwards AFB, California

Emissions Source (tons/12 flights/year)	**NO_x**	**VOC**	**PM_{10}**	**SO_x**	**CO**
Aircraft LTOs/flights (F-15, F-16, & C-130H)[a]	0.25	0.41	NA	NA	NA
Aerospace ground equipment	3.70	0.40	0.25	0.24	N/A
Ground support equipment	0.17	0.02	0.01	N/A	N/A
Total	4.12	0.83	0.26	0.24	N/A
De minimis thresholds	50	50	100	N/A	N/A
Kern County, MDAB portion of inventory	10,585	4,745	10,585	N/A	31,025
Percentage of inventory	<0.1	<0.1	<0.1	N/A	N/A

Notes: a - Does not include emissions above 3,000 feet above ground level.
CO - carbon monoxide
LTO - landing and takeoff
N/A - not applicable
NA - not available
NO_x - nitrogen oxides
PM_{10} - particulate matter ≤ 10 microns in diameter
POV - privately owned vehicle
SO_x - sulfur oxides
VOC - volatile organic compound

situated in the San Joaquin Valley Unified Air Pollution Control District, is not included in the conformity applicability analysis because the Valley portion is not anticipated to be affected by the proposed project. Table 4-1 indicates that the ozone precursor (NO_X and VOC) emissions and PM_{10} emissions would be less than the *de minimis* thresholds of 50 tons per year for a serious ozone nonattainment area and 100 tons per year for a PM_{10} nonattainment area such as the current MDAB portion of Kern County (40 CFR Part 93 Subpart 153[b][2]). In addition, the emissions of ozone precursors and PM_{10} would not exceed 10 percent of the total Kern County inventories (40 CFR Part 93 Subpart 153[i]). Based on the conformity applicability criteria, the proposed project conforms with the most recent EPA-approved SIP, and no further detailed conformity analysis is required.

In addition, there are no local concerns for CO within the ROI for the proposed project. Emissions from the proposed project would not result in any CO hot spots since traffic congestion and CO nonattainment in the ROI are not local issues.

The proposed project conforms with the most recent U.S. EPA-approved SIP and emissions from the proposed project would not result in any CO hot spots.

4.1.1.2 Off-Base Region

Emissions under the proposed project would only be generated in the on-base region, therefore, no off-base impacts to air quality would occur under Alternative A.

4.1.2 Alternative B (Northwestern Approach)

4.1.2.1 On-Base Region

On-base impacts under Alternative B would be identical to those under Alternative A.

4.1.2.2 Off-Base Region

As under Alternative A, no off-base impacts to air quality would occur.

4.1.3 Alternative C (No-Action)

Under the No-Action Alternative, the orbital reentry corridor would not be created, therefore, no on- or off-base impacts to air quality would occur.

4.2 AIRSPACE

Any proposed airspace use that requires operating in airspace not approved for that type of activity would result in a significant impact. Impacts would also be considered significant if they resulted in increased risk of aircraft mishaps, permanent changes to flight routes, or restriction of operations at airports.

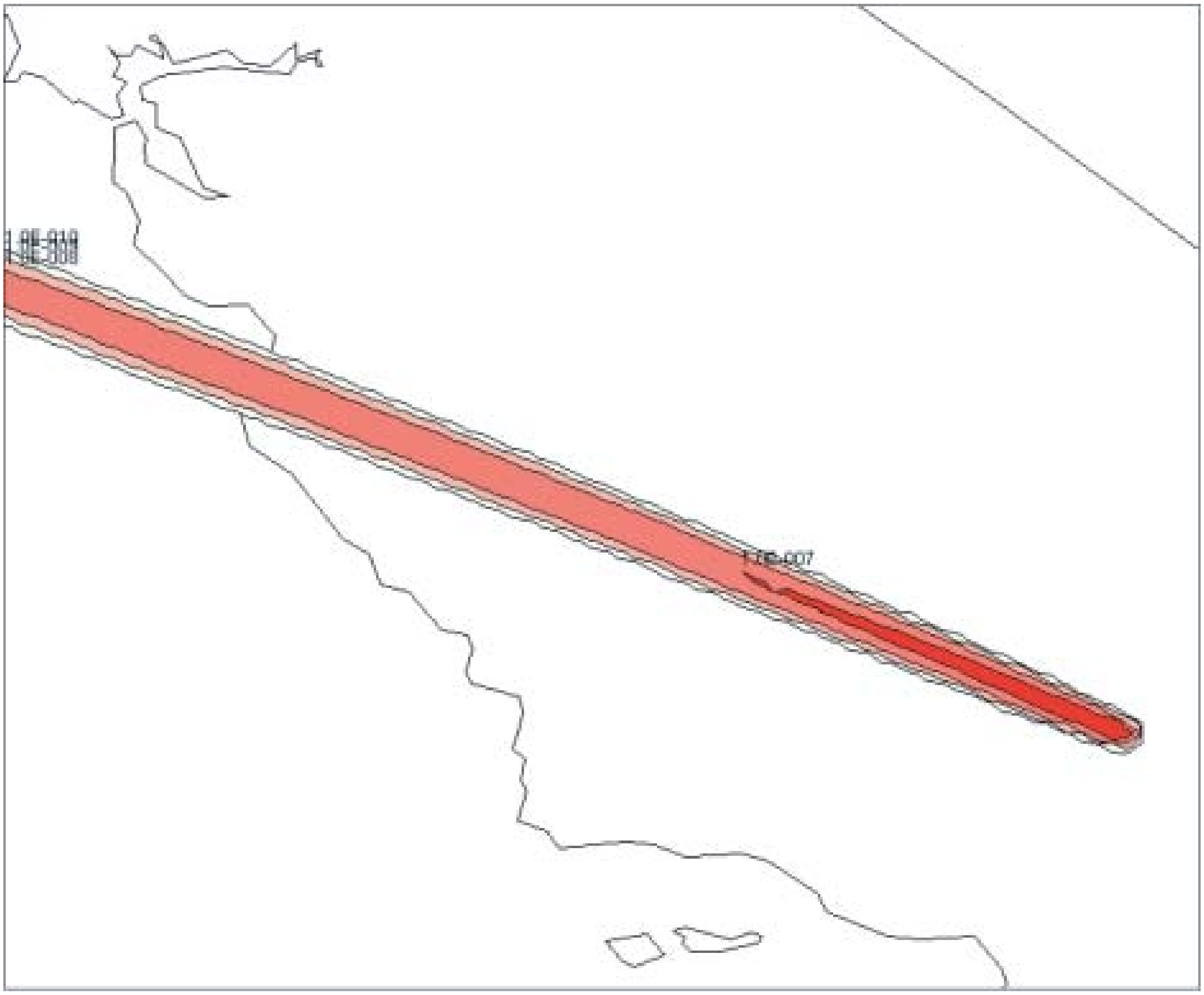
4.2.1 Alternative A (Western Approach)

The unmanned LEV utilizing the Western Approach Reentry Corridor would be above 108,000 feet when crossing the California coastline, and would not be below 100,000 feet until it was within 60 nautical miles of the HAC intercept at Edwards AFB, or approximately halfway between the coastline and the R-2515 restricted area (which extends from FL 200 to unlimited altitude). According to the QRA (see Appendix A), the maximum probability of a collision with an aircraft at any point outside of Edwards AFB would be less than 1 collision per 10 million failures, as shown in dark red on Figure 4-1. In most regions (those areas outside the dark red areas as shown on Figure 4-1) the probability of collision with an aircraft would be less than 1 collision in 100 million failures.

The potential for impacts to controlled and uncontrolled airspace, special use airspace, military training routes, en route airways and jet routes, airports/airfields, and air traffic control are discussed below.

4.2.1.1 Controlled and Uncontrolled Airspace

Establishment and use of an orbital reentry corridor would not affect the existing controlled and uncontrolled, or navigable, airspace in the Western Approach Reentry Corridor ROI. Due to the steep trajectory of the unmanned LEV, it does not enter the NAS (60,000 feet above msl) until it is approximately 11 miles from the HAC.



(SOURCE: U.S. Air Force 1975, 1978, no date [n.d.])

LEGEND

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🟥	1.0 x 10^{-8}
🟥	1.0 x 10^{-9}
☐	1.0 x 10^{-10}

EA for the Orbital Reentry Corridor for
Generic Unmanned Lifting Entry Vehicle
Landing at Edwards AFB

CONDITIONAL PROBABILITY OF FAILED LEV COLLISION WITH AN AIRCRAFT

Tetra Tech, Inc.
4213 State Street, Suite 100
Santa Barbara, CA 93110-2847

TASK NO.	DATE	DRAWN BY	AI FILE NO.	FIGURE NO.
Q202-0701	11/6/02	RANDALL	Graphic:\ EdwardsAFB\ Rentry\4-1 CollisionMap.ai	4-1

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The risk of collision with an aircraft is extremely low. The expected number of collisions between the unmanned LEV and an aircraft is less than 5 per billion missions. Based on the Range Commanders Council and Eastern and Western Range standards, no aircraft exclusion zones are necessary or required (AFFTC 2001). Therefore, impacts on controlled and uncontrolled airspace are not anticipated under normal conditions.

In the event of an emergency landing within the reentry corridor, the U.S. Air Force would relay all required airspace requests to TRACON for coordination with the Los Angeles ARTCC or the Oakland ARTCC. The ARTCC will be responsible for communications and coordination with affected terminal and flight service station facilities. Under emergency conditions there could be a temporary reduction in navigable airspace. Emergency situations are evaluated and handled by ATC on a case-by-case basis, whereby an emergency unmanned LEV or any aircraft experiencing an emergency would be afforded priority handling over all other traffic. Should the emergency landing location be outside the continental United States, but in airspace under United States jurisdiction, oceanic ATC facilities would coordinate with ATC facilities of other governments as appropriate or feasible.

4.2.1.2 Special Use Airspace

Establishment of an orbital reentry corridor would have no impacts on the existing special use airspace below the Western Approach Reentry Corridor. The offshore Warning Areas and the Restricted Areas associated with Vandenberg AFB are established for flights below 100,000 feet above msl. The unmanned LEV would be above all offshore Warning and Restricted Areas.

The LEV would enter the R-2508 and R-2515 restricted areas in the R-2508 Complex, however, these areas would not be adversely affected since accommodating unmanned LEV landings would be considered a matter of routine operations in that special use airspace. The agency using the restricted areas coordinates with the Central Coordinating Facility (CCF) who has the autonomous authority for the R-2508 Complex shared-use airspace. The CCF acts as the single point for coordination of activities with High Desert TRACON and other ATC/mission control facilities. In addition, the flight tests represent precisely the kind of activities for which the Restricted Area special use airspace was created in the early 1960s: namely, to accommodate national security and necessary military activities, and to confine or segregate activities considered to be hazardous to nonparticipating aircraft.

Any additional demands that would be placed on existing special use airspace could be accommodated by airspace schedulers. Alternative A would not require assignment of new special use airspace or modification of existing special use airspace. Consequently, there would be no adverse impacts to special use airspace.

The scheduling office for each special use airspace area (CCF within the R-2508 Complex) regulates the real-time activity schedule for any Restricted Area, MOA, or Warning Area that would be affected by an emergency landing. Special use airspace activities may be temporarily affected, but would be readily accommodated by airspace schedulers.

In the event of an emergency landing within the reentry corridor, the U.S. Air Force would relay all required airspace requests to TRACON via the CCF for special use airspace. Emergency situations are evaluated and handled by ATC on a case-by-case basis, with an emergency unmanned LEV or any aircraft experiencing an emergency being afforded priority handling over all other air traffic.

4.2.1.3 Military Training Routes

Establishment of an orbital reentry corridor would not affect military training routes below the Western Approach Reentry Corridor, Alternative A. Scheduling the use of R-2508 and the military training routes that transit that airspace is a normal function for the CCF. Therefore, no impacts would occur.

Use of Restricted Areas R-2508 and R-2515 in the R-2508 Complex for unmanned LEV landings would not have an adverse impact on military training routes within the complex. Each military training route's "Origination Activity" or home base, which is responsible for communications and coordination with the military aircraft scheduled to use the affected routes, would be notified of the unmanned LEV landing schedule, and military training would be scheduled to ensure the appropriate separation between aircraft and the unmanned LEV. Thus, there would be short-term reductions in the availability of entire training routes, or individual segments. However, the rescheduling of military training route exercises is routine and would not constitute an adverse impact.

In the event of an emergency landing within the reentry corridor, the U.S. Air Force would relay all required airspace requests for the affected routes to each military training route's "Origination Activity" or home base. During emergency conditions military aircraft would be re-scheduled, or routed around the airspace on a case-by-case basis, whereby an emergency unmanned LEV or any aircraft experiencing an emergency would be afforded priority handling over all other air traffic. Thus, there would be a temporary reduction in the availability of entire training routes, or individual segments.

4.2.1.4 En Route Airways and Jet Routes

Establishment of an orbital reentry corridor would not adversely affect the en route airways and jet routes, and general aviation VFR traffic, under the Western Approach Reentry Corridor. IFR aircraft using the en route airways and jet routes and VFR traffic below 18,000 feet would be vertically separated from the unmanned LEV's flight path by over 50,000 feet until the unmanned LEV enters the R-2508 Complex. There are no en route airways or jet routes that transect the R-2508 and R-2515 restricted areas in the R-2508 Complex that would be used for unmanned LEV landings, and therefore, no impacts would occur to en route airways or jet routes in this area.

General aviation VFR traffic below the R-2508 Restricted Area (which extends from FL 200 to an unlimited altitude) could potentially be affected by unmanned LEV landings within the R-2508 Complex. However, as noted above, the impacts would be short-lived and temporary with adequate notification provided by TRACON and local flight service stations.

In the event of an emergency landing within the entry corridor, the U.S. Air Force would relay landing requests to the FAA ATC Command Center for coordination with the Los Angeles ARTCC or the Oakland ARTCC. The ARTCC would provide traffic advisories to the extent possible to all aircraft operating in their affected airspace depending on higher priority duties of the controllers. Emergency situations are evaluated and handled by ATC on a case-by-case basis, with an emergency unmanned LEV or any aircraft experiencing an emergency being afforded priority handling over all other traffic. Under these emergency conditions there would be a temporary reduction in navigable airspace if air traffic is re-routed to avoid the emergency unmanned LEV. Should the emergency landing location be outside the continental United States, but in airspace under United States jurisdiction, oceanic ATC facilities would coordinate with ATC facilities of other governments as appropriate or feasible.

The FAA ARTCCs are responsible for air traffic flow control or management to ensure the smooth passage of air traffic through the CAE corridors off-shore under the orbital reentry corridor. The Los

Angeles or Oakland ARTCC provides separation services to aircraft operating on IFR flight plans and principally during the en route phases of the flight. Thus, although aircraft transiting the area may be required to change course to use a different CAE corridor during an emergency landing, this is already the normal, accepted procedure for aircraft transiting the CAE corridors through the Western Range, and thus no significant adverse impacts to en route airways and jet routes would result during emergency conditions.

4.2.1.5 Airports/Airfields

Establishment of an orbital reentry corridor would not adversely affect airports and airfields under the Western Approach Reentry Corridor. The unmanned LEV would be vertically separated from all airports and airfields outside the R-2508 Complex by over 60,000 feet. Specific airports, airfields, and private airstrips within the R-2508 Complex include the Rosamond (17 miles from Edwards AFB) and Taft-Kern County (100 miles from Edwards AFB) airports. Again, the vertical separation from these two airports would be in excess of 60,000 feet and the flight time over the airport control zones would be less than 10 seconds.

In the event of an emergency landing within the reentry corridor, the U.S. Air Force would relay all required airspace requests to the FAA ATC Command Center for coordination with the Los Angeles ARTCC or Oakland ARTCC. The ARTCC would provide traffic advisories to the extent possible to affected airports and airfields depending on higher priority duties of the controllers. Emergency situations affecting airports and airfields in the flight corridor would be evaluated and handled by ATC on a case-by-case basis, whereby an emergency unmanned LEV or any aircraft experiencing an emergency would be afforded priority handling over all other traffic. Under these emergency conditions there could be a temporary reduction in access to airports and airfields within the flight corridor when the unmanned LEV is maneuvered to an emergency landing site. Should the emergency landing location be outside the continental United States, but in airspace under United States jurisdiction, oceanic ATC facilities would coordinate with ATC facilities of other governments as appropriate or feasible.

4.2.1.6 Air Traffic Control

The unmanned LEV falls into the category of remotely operated aircraft, and as such, requires approval for operations in the R-2508 Complex. Chapter 2.7 of *The General Operating Procedures for R-2508 Complex* (Edwards Air Force Base 2001b) provides a detailed list of requirements for operating a remotely operated aircraft. The unmanned LEV is autonomous, with the only operator control provided by an up-link control of the flight termination system (FTS) that can be used to break the vehicle into seven pieces. Once the unmanned LEV begins its reentry from 400,000 feet in elevation, the FTS is operational. If the vehicle's flight profile deviates outside the parameters established by the safety plan, if there is a loss of signal, or if there is a loss of a specific data link command, the vehicle can be terminated by the Range Safety Officer.

As the unmanned LEV entered the NAS (FL 600), approximately 11 nautical miles from the HAC intercept, mission control would ensure that the trajectory flown by the unmanned LEV conformed to the planned reentry corridor.

The active reentry corridor would be dynamically reserved and released as the unmanned LEV proceeded along the flight path. With the assistance of conflict prediction and resolution advisories, ATC would ensure that non-participating aircraft remained separated from the active portion of the reentry corridor.

Because the unmanned LEV would be on either a gliding or ballistic return, positive ATC would not be an option since the vehicle cannot respond to the full range of ATC clearances. Upon reentry, these vehicles have a higher descent rate than powered vehicles and they, therefore, must anticipate any constraints to landing, since alternative trajectories must be exercised before the deorbit burn stage of reentry.

Trajectory modeling identifies the point at which the unmanned LEV is committed to land at Edwards AFB. This point represents the final opportunity to invoke a contingency plan to land at an alternate site if operational conditions are undesirable at Edwards AFB. Mission Control and ATC maintain communications in case a contingency plan must be implemented.

When the unmanned LEV reaches its commitment point, it is handled as a priority vehicle since it does not have the option of deviating from its landing plan. The NAS Decision Support System provides sequencing and scheduling advisories to create an arrival slot to accommodate the landing. When the unmanned LEV lands at Edwards AFB, AFFTC and NASA assume responsibility. When the vehicle touches down, the vehicle operator issues a notification that the mission has been completed, and the notification is disseminated via the NAS Wide Information System (FAA 2001).

Due to the small number of flights anticipated per year, no potential impacts on ATC are anticipated.

4.2.2 Alternative B (Northwestern Approach)

The unmanned LEV utilizing the Northwestern Approach Reentry Corridor would be above 160,000 feet when crossing the California/Oregon coastline, and would not be below 100,000 feet until within 60 nautical miles of the HAC intercept at Edwards AFB, or until it entered the R-2515 restricted area (which extends from FL 200 to unlimited altitude). The impact probability contour for debris impacting an aircraft below 100,000 feet above msl is 1 in 100 million (AFFTC 2001).

The potential for impacts to controlled and uncontrolled airspace, special use airspace, military training routes, en route airways and jet routes, airports/airfields, and air traffic control are discussed below.

4.2.2.1 Controlled and Uncontrolled Airspace

Similar to Alternative A, establishment and use of an orbital reentry corridor would not adversely affect the existing controlled and uncontrolled, or navigable, airspace in the Northwestern Approach Reentry Corridor ROI. Due to the steep trajectory of the unmanned LEV, it would not enter the NAS (60,000 feet above msl) until it was approximately 11 miles from the HAC.

The risk of collision with an aircraft is extremely low. The expected number of collisions between the unmanned LEV and an aircraft is less than 5 per billion missions. Based on the Range Commanders Council and Eastern and Western Range standards, no aircraft exclusion zones are necessary or required (AFFTC 2001). Therefore, impacts on controlled and uncontrolled airspace are not anticipated under normal conditions.

Again, in the event of an emergency landing within the reentry corridor, the U.S. Air Force would relay all required airspace requests to TRACON for coordination with the Los Angeles ARTCC or the Oakland ARTCC. Under emergency conditions there would be a temporary reduction in navigable airspace as air traffic was cleared from, and re-routed around, the airspace within plus or minus 5 minutes of the projected flight time of the unmanned LEV. Should the emergency landing location be outside the continental United States, ATC facilities would coordinate with ATC facilities of other governments as appropriate or feasible.

4.2.2.2 Special Use Airspace

Similar to Alternative A, establishment of an orbital reentry corridor would have no adverse impacts on the existing special use airspace below the Northwestern Approach Reentry Corridor. The R-2508 and R-2515 Restricted Areas in the R-2508 Complex would not be adversely affected since accommodating an unmanned LEV or other manned or unmanned aerospace vehicles would be considered a matter of routine operations for that special use airspace. The agency using the restricted areas coordinates with the CCF, which has autonomous authority for the R-2508 Complex shared-use airspace. The CCF acts as the single point for coordination of activities with High Desert TRACON and other ATC/mission control facilities.

Any additional demands that would be placed on existing special use airspace could be accommodated by airspace schedulers. Utilization of the Northwestern Approach Reentry Corridor would not require the assignment of new special use airspace or require the modification of existing special use airspace. Consequently, there would be no adverse impacts to special use airspace.

In the event of an emergency landing within the reentry corridor, the U.S. Air Force would relay all required airspace requests to TRACON via the CCF for special use airspace. Emergency situations are evaluated and handled by ATC on a case-by-case basis, whereby an emergency unmanned LEV or any aircraft experiencing an emergency would be afforded priority handling over all other air traffic. The scheduling office for each special use airspace area regulates the real-time activity schedule for any Restricted Area, MOA, or Warning Area that would be affected by an emergency landing. Special use airspace activities may be temporarily affected, but would be readily accommodated by airspace schedulers.

4.2.2.3 Military Training Routes

Similar to Alternative A, establishment of an orbital reentry corridor would not impact military training routes below the Northwestern Approach Reentry Corridor, Alternative B. Scheduling the use of R-2508 and the military training routes that transit that airspace is a normal function for TRACON. Therefore, no impacts would occur.

Use of Restricted Areas R-2515 and R-2508 in the R-2508 Complex for the proposed unmanned LEV landings would not have an adverse impact on military training routes within the complex because rescheduling of military training route exercises is routine and would not constitute an adverse impact.

In the event of an emergency landing within the entry corridor, each military training route's "Origination Activity" or home base, would be responsible for communications and coordination with the military aircraft using, or scheduled to use, the affected routes. There would be a temporary reduction in the availability of entire training routes, or individual segments.

4.2.2.4 En Route Airways and Jet Routes

Establishment of an orbital reentry corridor would have no impact to en route airways and jet routes under the Northwestern Approach Reentry Corridor outside or inside of the R-2508 Complex. Unmanned LEVs utilizing the entry corridor would be above 160,000 feet above msl when crossing the Oregon-California border, and would not be below 100,000 feet until within 60 nautical miles of the HAC intercept at

Edwards AFB, well within the western boundary of the R-2508 Complex, which extends from the surface to unlimited altitude. The NAS would not be entered until the unmanned LEV is approximately 11 miles from the HAC at an altitude of 60,000 feet msl. As a result, there would be no en route airways or jet routes in the affected flight path of an unmanned LEV under Alternative B. The closest, the J110 jet route, lies north of the northwestern corridor. Thus, an existing or planned IFR minimum flight altitude, a published or special instrument procedure, an IFR departure procedure, or an existing or planned VFR operation, would not be required to change from a regular flight course or altitude.

Under normal landing conditions (similar to the Space Shuttle Orbiter landing on Runway 22 at Edwards AFB), general aviation VFR traffic below the R-2508 Restricted Area (which extends from FL 200 to an unlimited altitude) would continue to transit the area below 18,000 feet msl. Although J-110 intersects the R-2508 Restricted Area northwest of Runway 22, the flight path of the unmanned LEV would cross that area above 100,000 feet above msl; thus no impacts are anticipated under normal approach conditions.

In the event of an emergency landing within the reentry corridor, the U.S. Air Force would relay all required airspace requests to the FAA ATC Command Center via the CCF for coordination with the Los Angeles, Oakland, or Seattle ARTCC. The ARTCC would provide traffic advisories to the extent possible to all aircraft operating in their affected airspace depending on higher priority duties of the controllers. Emergency situations are evaluated and handled by ATC on a case-by-case basis, whereby an emergency unmanned LEV or any aircraft experiencing an emergency would be afforded priority handling over all other traffic. Under these emergency conditions there would be a temporary reduction in navigable airspace as air traffic is re-routed to avoid the emergency unmanned LEV. Should the emergency landing location be outside the continental United States, but in airspace under United States jurisdiction, oceanic ATC facilities would coordinate with ATC facilities of other governments as appropriate or feasible.

4.2.2.5 Airports/Airfields

Establishment of an orbital reentry corridor would have no impacts to airports and airfields under the Northwestern Approach Reentry Corridor. The unmanned LEV would be vertically separated from all airports and airfields outside the R-2508 Complex by more than 60,000 feet. Specific airports, airfields, and private airstrips within the R-2508 Complex include the California City (19 miles from Edwards AFB) and Kern Valley (100 miles from Edwards AFB) airports. Again, the vertical separation from these two airports would be in excess of 60,000 feet and the flight time over the airport control zones would be less than 10 seconds.

In the event of an emergency landing within the reentry corridor, the U.S. Air Force would relay all required airspace requests to the FAA ATC Command Center for coordination with the Los Angeles, Oakland, or Seattle ARTCC. The ARTCC would provide traffic advisories to the extent possible to affected airports and airfields depending on higher priority duties of the controllers. Emergency situations affecting airports and airfields in the flight corridor would be evaluated and handled by ATC on a case-by-case basis, whereby an emergency unmanned LEV or any aircraft experiencing an emergency would be afforded priority handling over all other traffic. Under these emergency conditions there could be a temporary reduction in access to airports and airfields within the flight corridor when the unmanned LEV is maneuvered to an emergency landing site. Should the emergency landing location be outside the continental United States, but in airspace under United States jurisdiction, oceanic ATC facilities would coordinate with ATC facilities of other governments as appropriate or feasible.

4.2.2.6 Air Traffic Control

Impacts to air traffic control under Alternative B would be identical to those under Alternative A.

4.2.3 Alternative C (No-Action)

Under the No-Action Alternative a high speed/high altitude entry corridor for unmanned LEVs would not be established at Edwards AFB. Consequently, no impacts to airspace would occur.

4.3 CULTURAL RESOURCES

Cultural resources are limited, nonrenewable resources whose potential for scientific research or value as a traditional resource may be easily diminished by actions that significantly impact the integrity of the property. Potential impacts to historic properties are assessed by applying the Criteria of Adverse Effect as defined in 36 CFR 800.5a. "An adverse effect is found when an action may alter the characteristics of a historic property that qualify it for inclusion in the National Register in a manner that would diminish the integrity of the property's location, design, setting, workmanship, feeling, or association. Adverse effects may include reasonably foreseeable effects caused by the action that may occur later in time, be farther removed in distance, or be cumulative." The Criteria of Adverse Effect provide a general framework for identifying and determining the context and intensity of potential impacts to other categories of cultural resources, as well, if these are present. Assessment of effects involving Native American or other traditional community, cultural or religious practices or resources requires focused consultation with the affected group.

Potential impacts to cultural resources associated generally with airspace use include physical damage to buildings, structures or rock features through accident or vibration, visual or audible impacts to the setting of cultural resources, and disturbance of traditional activities such as religious ceremonies or subsistence hunting. Impacts to cultural resources from airspace use are most likely to be related to alterations in setting from visual or aural disturbance and the extremely remote possibility of the crash or breakup of a vehicle.

4.3.1 Alternative A (Western Approach)

4.3.1.1 On-Base Region

The unmanned LEV has the option to land at Rogers Dry Lake, a National Historic Landmark. The continued use of the landmark in assessing leading-edge space technology enhances its role in the history of technological advances in aviation and aerospace. There would be no adverse effects on this landmark.

The breakup of the unmanned LEV during a crash and subsequent recovery activities could directly impact base cultural resources including sites listed on the National Register. The best estimate of the probability of failure during descent of the unmanned LEV was determined to be 3 in 1,000 (see Appendix A). If the unmanned LEV were to crash, it would either crash intact or break into its seven components. The probability of hitting specific assets on the ground is comparable to the probability of casualty to humans, which is estimated to be less than 5 in 1 million missions (see Appendix A). Because the probability of a crash is low, impacts to cultural resources as a result are not anticipated.

4.3.1.2 Off-Base Region

The breakup of the unmanned LEV during a crash and recovery activities afterward could directly impact off-base cultural resources including sites on the National Register. Again, the best estimate of the probability of failure during descent of the unmanned LEV was determined to be 3 in 1,000 (see Appendix A). If the unmanned LEV were to crash, it would either crash intact or break into its seven components. The probability of hitting specific assets on the ground is comparable to the probability of casualty to humans which is estimated to be less than 5 in 1 million missions (see Appendix A). Because the probability of a crash is low, impacts to cultural resources as a result are not anticipated.

Noise levels generated during sonic booms that would occur during landing of the unmanned LEV are not anticipated to impact historic buildings, structures, or rock features. There is only a slight chance of damage to windows, plaster, and bric-a-brac in structures between 17 and 30 nautical miles (20 to 30 statute miles) from Edwards AFB. The probability of glass breakage, however, would be between 1 and 23 window panes per 1 million panes. Due to the low probability of damage to structures, impacts to off-base cultural resources due to structure damage caused by sonic booms are not anticipated. In addition, noise levels generated during sonic booms that would occur during landing of the unmanned LEV would be less than 61 dB, the threshold for impacts to residential areas (see section 4.10, Noise) and the unmanned LEV would not be within sight until it was less than 5 miles from Edwards AFB. Therefore, no visual or noise impacts on cultural properties or practices are anticipated under Alternative A.

4.3.2 Alternative B (Northwestern Approach)

4.3.2.1 On-Base Region

Impacts to on-base cultural resources under Alternative B would be identical to those under Alternative A.

4.3.2.2 Off-Base Region

The potential for impacts to off-base cultural resources under Alternative B is similar to those described for Alternative A, except that the Northwestern Approach Reentry Corridor only passes over a large portion of the Tule River Reservation. The approach corridor under Alternative B is much larger than under Alternative A, increasing the risk of a crash impact to off-base cultural resources. Despite this increased risk, there is still a low probability of an unmanned LEV crash and a low probability of structure damage associated with sonic booms. Therefore, impacts to off-base cultural resources under Alternative B as a result of a crash or sonic boom noise levels are not anticipated.

4.3.3 Alternative C (No-Action)

Under the No-Action Alternative, the orbital reentry corridor would not be created, therefore, no- on or off-base impacts to cultural resources would occur.

4.4 ENVIRONMENTAL JUSTICE

The Environmental Justice Interagency Working Group, mandated by Executive Order 12898, developed guidance for determining whether an impact to human health or the environment would result in disproportionately high and adverse impacts to minority and/or low income populations. The Working Group recommends considering the following six factors to the extent practicable.

1. Whether there is or will be an impact on the natural or physical environment that significantly and adversely affects a minority or low-income population. Such effects may include ecological, cultural, human health, economic, or social impacts on minority communities or low-income communities when those impacts are interrelated to impacts on the natural or physical environment.
2. Whether environmental effects are significant and are or may be having an adverse impact on minority populations that appreciably exceeds or are likely to appreciably exceed those on the general population or other appropriate comparison group.
3. Whether the environmental effects occur or would occur in a minority and/or low-income population affected by cumulative or multiple adverse exposures from environmental hazards.
4. Whether the health effects, which may be measured in risks and rates, are significant, or above generally accepted norms. Adverse health effects may include bodily impairment, infirmity, illness, or death.
5. Whether the risk or rate of hazard exposure by a minority population or low-income population to an environmental hazard is significant and appreciably exceed or is likely to appreciably exceed those on the general population or other appropriate comparison group.
6. Whether health effects occur in a minority population or low-income population affected by cumulative or multiple adverse exposures from environmental hazards.

4.4.1 Alternative A (Western Approach)

4.4.1.1 On-Base Region

Since no new development would be required under the Orbital Reentry Corridor Program and current Air Force and contractor personnel from other bases would be used for the program, Alternative A would not have an impact on the health or environment of minority or low-income populations on-base. In addition, no impacts would occur to socioeconomics (Section 4.13), noise (Section 4.10), air quality (Section 4.1), safety (Section 4.12), and hazardous waste/hazardous materials (Section 4.6).

4.4.1.2 Off-Base Region

Since no new development would be required under the Orbital Reentry Corridor Program and current Air Force and contractor personnel from other bases would be used for the program, Alternative A would not have an impact on the health or environment of minority or low-income populations off-base. In addition, the method of corridor selection for reentry of the LEV did not rely on or factor in the locations of minority or low-income populations.

4.4.2 Alternative B (Northwestern Approach)

4.4.2.1 On-Base Region

The on-base impacts of Alternative B would be identical to those of Alternative A.

4.4.2.2 Off-Base Region

The off-base environmental justice impacts expected from Alternative B would be identical to those described for Alternative A.

4.4.3 Alternative C (No-Action)

Under the No-Action Alternative, the orbital reentry corridor would not be created, therefore, there would be no on- or off-base impacts to the health or environment of minority or low-income populations in surrounding communities.

4.5 GEOLOGY AND SOILS

A project may result in a significant geologic impact if it increases the likelihood of, or results in exposure to earthquake damage, slope failure, foundation instability, land subsidence, or other severe geologic hazards. It may also be considered a significant geologic impact if it results in the loss of the use of soil for agriculture or habitat, loss of aesthetic value from a unique landform, loss of mineral resources, or severe erosion or sedimentation.

4.5.1 Alternative A (Western Approach)

4.5.1.1 On-Base Region

Alternative A would use either concrete Runway 22 or the Rogers Dry Lakebed for landing. No construction activities would be required since both locations are routinely used for landing other aircraft. Continued landing on the Rogers Dry Lakebed has the potential to affect the geology and soils in the lakebed, but, because landing routinely takes place there, landing the unmanned LEV on the lakebed is not anticipated to increase erosion.

The breakup of the unmanned LEV during a crash and subsequent recovery activities could cause ground disturbance and, therefore, would directly impact geology and soils on base. The best estimate of the probability of failure during descent of the unmanned LEV was determined to be 3 in 1,000 (see Appendix A). If the unmanned LEV were to crash, it would either crash intact or break into its seven components. The probability of hitting specific assets on the ground is comparable to the probability of casualty to humans, which is estimated to be less than 5 in 1 million missions (see Appendix A). The trajectory for the unmanned LEV would be at elevations much higher than the highest peaks on-base under Alternative A. Because the probability of a crash is low, impacts to base geology and soils as a result of a crash are not anticipated.

4.5.1.2 Off-Base Region

The breakup of the unmanned LEV during a crash and subsequent recovery activities could directly impact off-base geology and soils through ground disturbance. The best estimate of the probability of failure during descent of the unmanned LEV was determined to be 3 in 1,000 (see Appendix A). The trajectory for the unmanned LEV would be at elevations much higher than the highest peaks off-base under Alternative A. Because the probability of a crash is low, impacts to off-base geology and soils as a result of a crash are not anticipated.

4.5.2 Alternative B (Northwestern Approach)

4.5.2.1 On-Base Region

Impacts to geology and soils generated under Alternative B would be identical to those for Alternative A.

4.5.2.2 Off-Base Region

The breakup of the unmanned LEV during a crash and subsequent recovery activities could directly impact off-base geology and soils through ground disturbance. The best estimate of the probability of failure during descent of the unmanned LEV was determined to be 3 in 1,000 (see Appendix A). If the unmanned LEV were to crash, it could either crash intact or break into its seven components. The probability of hitting specific assets on the ground is comparable to the probability of casualty to humans, which is estimated to be less than 5 in 1 million missions (see Appendix A). The trajectory for the unmanned LEV would be at elevations much higher than the highest peaks off-base under Alternative B. Because the probability of a crash is low, impacts to off-base geology and soils as a result of a crash are not anticipated.

4.5.3 Alternative C (No-Action)

Under the No-Action Alternative, the orbital reentry corridor would not be established and no increase in the use of Runway 22 or the Rogers Dry Lakebed would occur. Therefore, no impacts to geology and soils would occur under Alternative C.

4.6 HAZARDOUS WASTE/HAZARDOUS MATERIALS

A project may result in a significant hazardous waste/hazardous materials impact if it increases the potential for exposure to hazardous waste/hazardous materials or increases the likelihood of a hazardous materials release to the environment. Impacts to hazardous materials and waste management would also be considered significant if they resulted in noncompliance with applicable regulatory guidelines or increased the amounts generated beyond available waste management capacities.

Impacts to solid waste would be considered significant if they resulted in noncompliance with applicable regulatory guidelines or increased the amounts generated beyond available waste management capacities.

4.6.1 Alternative A (Western Approach)

As previously described, this EA only addresses the reentry and landing phases of the Orbital Reentry Corridor Program. Hazardous materials would not be used for, and solid waste or hazardous waste would not be generated from, the reentry and landing phases of the Orbital Reentry Corridor Program. Hazardous materials and wastes involved in other phases of the program (e.g., vehicle fabrication, launch, refurbishment, flights with specific payloads) would be addressed in separate environmental documentation.

If a crash were to occur there is a small probability that an on-base IRP site could be impacted. If a crash occurred on an IRP site, hazardous wastes within that site could be affected. The best estimate of the probability of failure during descent of the unmanned LEV was determined to be 3 in 1,000 (see Appendix A). If the unmanned LEV were to crash, it would either crash intact or break into its seven components. The probability of hitting specific assets on the ground is comparable to the probability of casualty to humans which is estimated to be less than 5 in 1 million missions (see Appendix A). Since the probability of a crash is low, impacts to on-base hazardous wastes within IRP sites are not anticipated.

If a crash were to occur, Edwards AFB would be responsible for disposing of the debris and an impact to solid waste would occur. However, because the probability of a crash is low, impacts to solid waste are not anticipated.

4.6.2 Alternative B (Northwestern Approach)

Impacts to hazardous waste/hazardous materials and solid waste under Alternative B would be identical to those described under Alternative A.

4.6.3 Alternative C (No-Action)

Under the No-Action Alternative, the orbital reentry corridor would not be established, therefore, impacts to hazardous waste/hazardous materials would not occur.

4.7 INFRASTRUCTURE

A project may have significant effects on a public utility if it increases demand in excess of utility system capacity to the point that substantial expansion becomes necessary. Significant environmental impacts could also result from system deterioration due to improper maintenance or extension of service beyond its useful life. Destruction or damage of infrastructure would also be considered a significant impact.

4.7.1 Alternative A (Western Approach)

4.7.1.1 On-Base Region

Energy Resources

As described previously, this EA only addresses the reentry and landing phases of the Orbital Reentry Corridor Program. Energy resources utilized in other phases of the program (e.g., vehicle fabrication, launch, refurbishment) would be addressed in separate environmental documentation. No new development would be required for the Orbital Reentry Corridor Program and current Air Force or contractor personnel from other bases would be used for the program. Therefore, no impacts to on-base energy resources are anticipated to be generated from Alternative A.

Water Distribution System

The reentry and landing phases of Alternative A are not anticipated to require any increase in on-base water use.

Wastewater/Storm Water Treatment

The reentry and landing phases of Alternative A would not directly affect the sewer system or any wastewater management facility on-base. The wastewater treatment plant operated by Edwards AFB has a capacity of 2.5 million gallons per day and currently operates below capacity. No new development would be required for the Orbital Reentry Corridor Program and current Air Force or contractor personnel from other bases would be used for the program. Since the treatment plant operates below capacity, and since no increase in wastewater would occur, no impacts from Alternative A on the quantity or quality of wastewater discharged to the plant are anticipated. The reentry and landing phases of the vehicle test program would not affect storm water treatment at Edwards AFB.

Electrical Distribution System

Since no new facilities would be constructed, no impacts on the supply of electric power provided by Southern California Edison would occur under Alternative A. The current system is projected to meet all of DFRC's electrical demand, estimated at 40–45 megavolt-amperes, for the next 50 years. Therefore, Alternative A would not impact the supply of on-base electricity.

Natural Gas Distribution System

The existing on-base natural gas trunk lines are expected to be adequate for the next 50 years. Since no new facilities would be constructed under Alternative A, no impacts to the on-base supply of natural gas would occur.

Communication Systems

Since Alternative A would not require any construction, the communication systems at Edwards AFB would not be affected.

Transportation System

No new or specialized equipment would be required to support the unmanned LEV approach and landing. Since no new development would be required for the Orbital Reentry Corridor Program and current Air Force or contractor personnel from other bases would be used for the program, no impacts to base transportation are anticipated.

4.7.1.2 Off-Base Region

The breakup of the unmanned LEV during a crash and subsequent recovery activities could directly impact off-base infrastructure if any major energy source, utility system, or transportation route were hit. The best estimate of the probability of failure during descent of the unmanned LEV was determined to be 3 in 1,000 (see Appendix A). If the unmanned LEV were to crash, it would either crash intact or break into its seven components. The probability of hitting specific assets on the ground is comparable to the probability of casualty to humans, which is estimated to be less than 5 in 1 million missions (see Appendix A). Because the probability of a crash is low, impacts to off-base infrastructure as a result of a crash are not anticipated.

4.7.2 Alternative B (Northwestern Approach)

4.7.2.1 On-Base Region

Impacts to on-base infrastructure resources under Alternative B would be identical to those described for Alternative A.

4.7.2.2 Off-Base Region

Impacts to off-base infrastructure resources under Alternative B would be similar to those described for Alternative A. However, because the corridor under Alternative B is larger, there is a greater risk of an impact during a crash than Alternative A. Nevertheless, because the probability of hitting any infrastructure is still relatively low, impacts to off-base infrastructure under Alternative B as a result of a crash are not anticipated.

4.7.3 Alternative C (No-Action)

Under the No-Action Alternative the orbital reentry corridor would not be established. Therefore, no impacts to infrastructure would occur.

4.8 LAND USE

An impact to land use would be considered significant if the project resulted in nonconformance with approved land use plans; conversion of prime agricultural land to other uses or a decrease in its productivity; a decrease in visual or aesthetic resources; or conflict with environmental plans or goals, permit requirements, or existing uses of the project area or other properties.

4.8.1 Alternative A (Western Approach)

4.8.1.1 On-Base Region

The Orbital Reentry Corridor Program would include the use of existing NASA DFRC facilities, and existing Runway 22 or the Rogers Dry Lakebed. Since no changes in land use or effects on visual or aesthetic resources would occur on-base, Alternative A would have no impact on land use.

4.8.1.2 Off-Base Region

No land uses changes would occur off-base as a result of the Orbital Entry Corridor Program. Since the unmanned LEV would be at very high altitudes (108,000 feet above msl when it crossed the California coast and 10,000 feet above msl at 7.9 statute miles from Runway 22), inland and offshore resources below the Alternative A corridor, including national parks and marine sanctuaries, would not be affected. In addition, the unmanned LEV would be out of sight until it was less than 5 miles from Edwards AFB and would not impact visual or aesthetic resources. Therefore, no impacts to off-base land uses would occur as a result of Alternative A.

4.8.2 Alternative B (Northwestern Approach)

4.8.2.1 On-Base Region

On-base impacts under Alternative B would be identical to those under Alternative A, therefore, no impacts to on-base land use would occur.

4.8.2.2 Off-Base Region

Since the unmanned LEV would be at very high altitudes (160,000 feet above msl when it crossed the Oregon coast and 10,000 feet above msl at 7.9 statute miles from Runway 22), inland and offshore resources below the Alternative B corridor, including national parks and marine sanctuaries, would not be affected. In addition, the unmanned LEV would be out of sight until it was less than 5 miles from Edwards AFB and would not impact visual or aesthetic resources. Therefore, no impacts to off-base land uses would occur as a result of Alternative B.

4.8.3 Alternative C (No-Action)

Under the No-Action Alternative, the Orbital Reentry Corridor Program would not be implemented, therefore, no impacts to land use would occur.

4.9 NATURAL RESOURCES

Impacts to natural resources would be considered significant if they resulted in harm, harassment, or destruction of any endangered, threatened, or rare species including a species proposed for listing, candidate species, or species considered sensitive by resource agencies or organizations (e.g., CDFG, CNPS). This would include impacts to designated critical habitat, migratory birds, wildlife migration corridors, or breeding areas. The loss of a substantial number of individuals of any native plant or animal species that could affect abundance or diversity of that species beyond normal variability is also considered significant. Any impacts to sensitive habitats may be considered significant.

4.9.1 Alternative A (Western Approach)

4.9.1.1 On-Base Region

Alternative A would use either concrete Runway 22 or the Rogers Dry Lakebed for landing. No construction activities would be required since both are routinely used for landing other aircraft, so no loss of habitat is anticipated. In addition, Rogers Dry Lake is not within designated critical habitat for the desert tortoise or within any SEA. Sensitive species and their habitat, including the desert tortoise and its designated critical habitat and SEAs, would not be impacted by Alternative A.

The breakup of the unmanned LEV during a crash and subsequent recovery activities could directly impact natural resources on-base through ground disturbance, especially designated critical habitat for the federally listed desert tortoise. The best estimate of the probability of failure during descent of the unmanned LEV was determined to be 3 in 1,000 (see Appendix A). If the unmanned LEV were to crash, it would either crash intact or break into its seven components. The probability of hitting specific assets on the ground is comparable to the probability of casualty to humans which is estimated to be less than 5 in 1 million missions (see Appendix A). Because the probability of a crash is low, impacts to base natural resources as a result of a crash are not anticipated.

4.9.1.2 Off-Base Region

Similar to on-base impacts, Alternative A would not require any development or change in off-base habitat. In addition, the reentry corridor would be at elevations well above the migration corridors for birds, including the Pacific Flyway. However, if an unmanned LEV were to crash off-base, sensitive natural resources could be impacted through ground disturbance. Since the probability of an unmanned LEV crash is low, impacts to off-base natural resources as a result of a crash are not anticipated.

Landing of the unmanned LEV would cause a sonic boom in the off-base region (see Sections 3.10 and 4.10), which could have impacts on wildlife. Wildlife response to noise can be physiological or behavioral. Physiological effects can be mild, such as an increase in heart rate, to more severe, such as effects on metabolism and hormone balance. Behavioral responses can also be mild, such as head raising or body shifting, to more severe, such as nest abandonment. Long-term exposure to noise can cause excessive stimulation to the nervous system and chronic stress that is harmful to the health of wildlife species and their reproductive fitness (Fletcher 1980, 1988).

Noise levels associated with a sonic boom from the unmanned LEV would be greatest between 17 and 30 nautical miles (20 and 35 statute miles) from Edwards AFB under the Alternative A corridor. CDNL noise levels generated during sonic booms that would occur during landing of the unmanned LEV would be less than 61 dB averaged over a 24-hour period, the threshold for impacts to residential areas (see Section 4.10). Noise levels generated during sonic booms would be short-term in nature and overall predicted noise levels would not exceed ambient noise levels in residential areas (61 dB). However, a CSEL of 100.4 dB would occur for approximately 1 second during the sonic boom within 17 and 30 nautical miles (20 and 35 statute miles) of Edwards AFB and up to 85.4 dB for 1 second, as far out as 1,000 nautical miles (1,176 statute miles) from Edwards AFB. Because these CSEL levels are above 61 dBC, the acceptable threshold for ambient conditions, sonic boom noise could elicit a short-term startle response in humans and wildlife, especially bird populations (see Section 4.10 below). However, because these noise levels would be significantly less than those experienced by the Space Shuttle, and would occur infrequently over the course of a year, these short-term noise impacts would be less than significant.

4.9.2 Alternative B (Northwestern Approach)

4.9.2.1 On-Base Region

On-base impacts under Alternative B would be identical to those under Alternative A.

4.9.2.2 Off-Base Region

Impacts to off-base natural resources under Alternative B would be similar to those under Alternative A. However, because the corridor under Alternative B is larger, there is a greater risk of a crash impact to natural resources under Alternative B than under Alternative A. Nevertheless, because the probability of a crash is still relatively low, impacts to off-base natural resources under Alternative B as a result of a crash are not anticipated.

4.9.3 Alternative C (No-Action)

Under the No-Action Alternative, the orbital reentry corridor would not be established, therefore, no impacts to natural resources would occur.

4.10 NOISE

Noise impact criteria are based on land use compatibility guidelines and on factors related to the duration and magnitude of noise level changes. Annoyance effects are the primary consideration for most noise impact assessments. Because the reaction to noise level changes involves both physiological and psychological factors, the magnitude of a noise level change can be as important as the resulting overall noise level. A readily noticeable increase in noise levels would often be considered a significant effect by the local residents, even if the overall noise level is still within land use compatibility guidelines. On the other hand, noise level increases that are unnoticed by most people are not considered a significant change, even if the overall noise level is somewhat above land use compatibility guidelines. Some potentially significant thresholds include the following:

- Project-related overpressures above 1 pound per square foot would have the potential to break glass or cause damage to structures, and therefore, would be considered a significant impact.

- An L_{DN} of 65 dBA, or a CDNL of 61 dBC for sonic booms, is the generally accepted limit for outdoor noise levels in residential areas for land use planning and long-term annoyance factors (Departments of the Air Force, Army, and Navy 1978; HUD 1978). Project-related noise levels 5 dB or more above 65 dBA or above 61 dBC would be considered a significant impact.

- Frequent occurrence of a CSEL greater than the generally accepted limit for outdoor noise levels of 61 dBC.

An Air Force prediction model (Boom 10c) was used to conduct sonic boom modeling for the proposed project. The vehicle flight profile, from 400,000 feet altitude to where the vehicle speed falls to subsonic velocity near Edwards AFB, was used to model typical sonic booms that would result from landing at Edwards AFB. Figure 4-2 presents the sonic boom overpressures and the lateral cutoff distance as a function of distance from Edwards AFB.

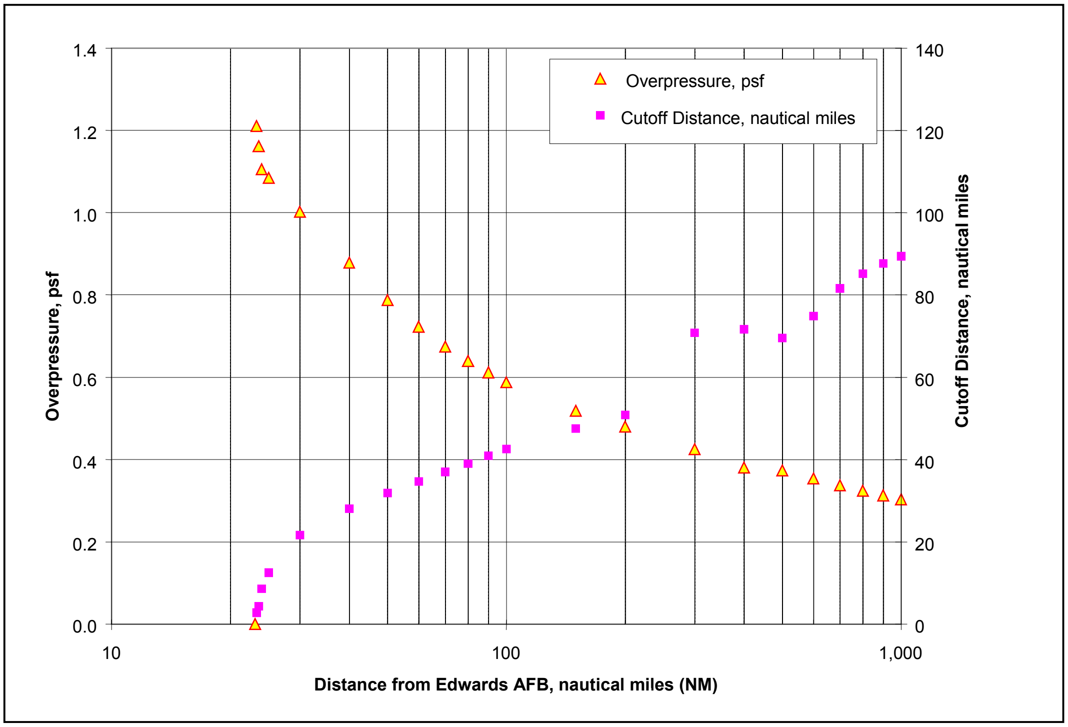


Figure 4-2 Estimated Sonic Boom Overpressures and Lateral Cutoff Distances for the Proposed Project

The magnitude of the sonic boom increases as the vehicle approaches Edwards AFB as the unmanned LEV is losing speed and altitude. The maximum sonic boom overpressures that are predicted to occur would be approximately 1.2 pounds per square foot and would occur between 20 and 30 nautical miles (20 and 35 statute miles) from the base. Typical overpressures experienced during past Space Shuttle landings over southern California have been below 2 pounds per square foot. Figures 4-3 and 4-4 show the sonic boom overpressure contours for the Space Shuttle landings under corridors corresponding to the Alternative A approach and Alternative B approach, respectively

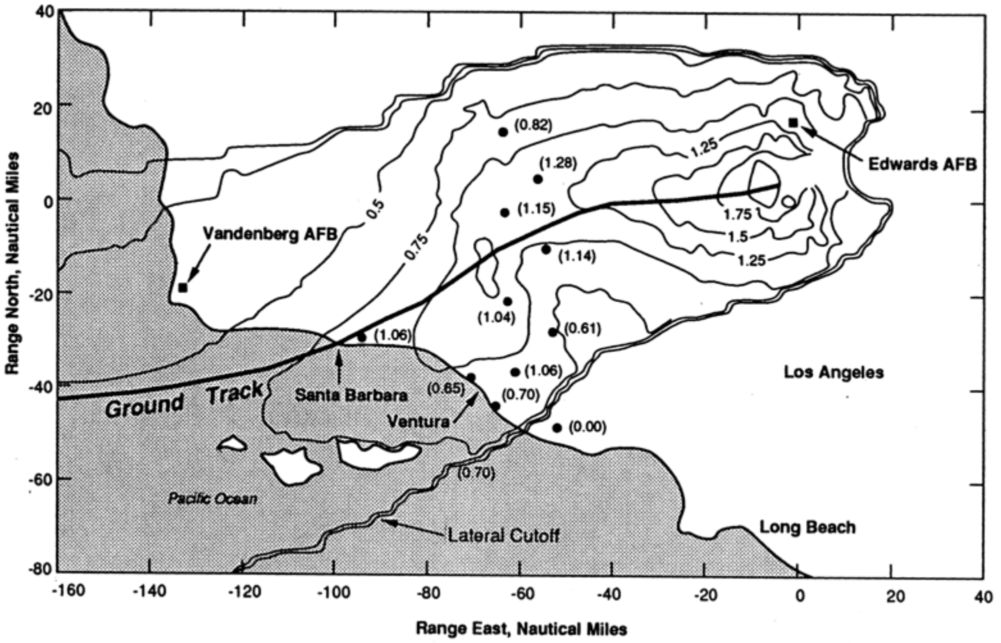

Range North, Nautical Miles
40
20
0
-20
-40
-60
-80
Range East, Nautical Miles
-160
-140
-120
-100
-80
-60
-40
-20
0
20
40
Vandenberg AFB
Edwards AFB
Los Angeles
Long Beach
Santa Barbara
Ventura
Pacific Ocean
Ground Track
Lateral Cutoff
0.5
0.75
1.25
1.75
1.5
1.25
(0.82)
(1.28)
(1.15)
(1.14)
(1.04)
(1.06)
(0.61)
(1.06)
(0.65)
(0.70)
(0.00)
(0.70)

Figure 4-3
Sonic Boom Overpressures for Shuttle Landing (Alternative A)

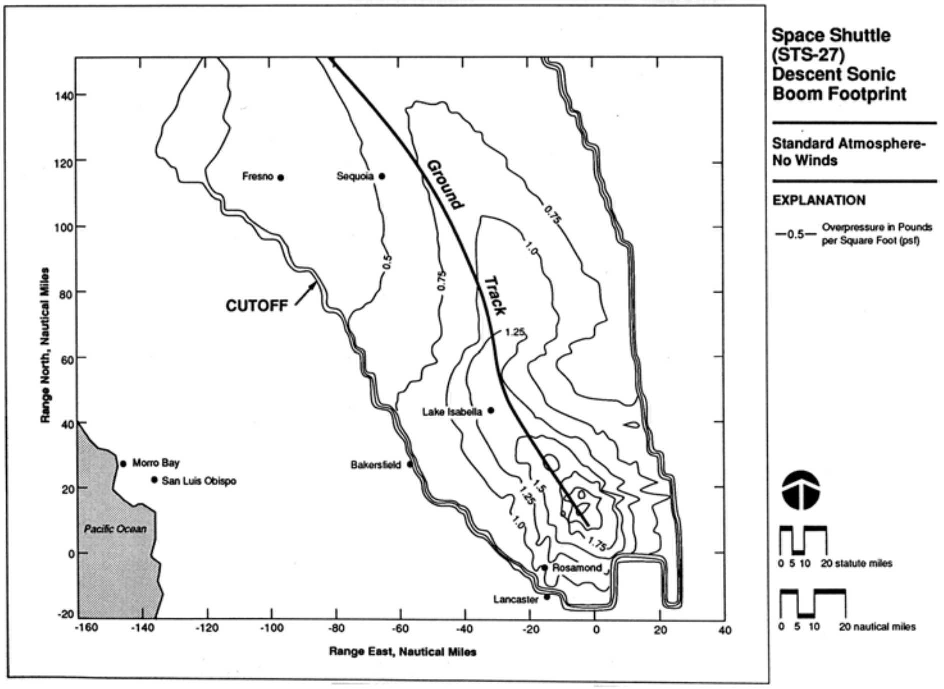

Space Shuttle
(STS-27)
Descent Sonic
Boom Footprint
Standard Atmosphere-
No Winds
EXPLANATION
—0.5— Overpressure in Pounds per Square Foot (psf)
0 5 10 20 statute miles
0 5 10 20 nautical miles
Range North, Nautical Miles
140
120
100
80
60
40
20
0
-20
Range East, Nautical Miles
-160
-140
-120
-100
-80
-60
-40
-20
0
20
40
Fresno
Sequoia
Lake Isabella
Bakersfield
Morro Bay
San Luis Obispo
Rosamond
Lancaster
Pacific Ocean
CUTOFF
Ground
Track
0.5
0.75
0.75
1.0
1.25
1.5
1.25
1.0
1.75

Figure 4-4
Sonic Boom Overpressures for Shuttle Landing (Alternative B)

The lateral cutoff distances are similar to those of the Space Shuttle landing. The sonic boom overpressure would decrease gradually with distance from the flight path and then decrease sharply at the lateral cutoff distance as shown in Figure 4-5.

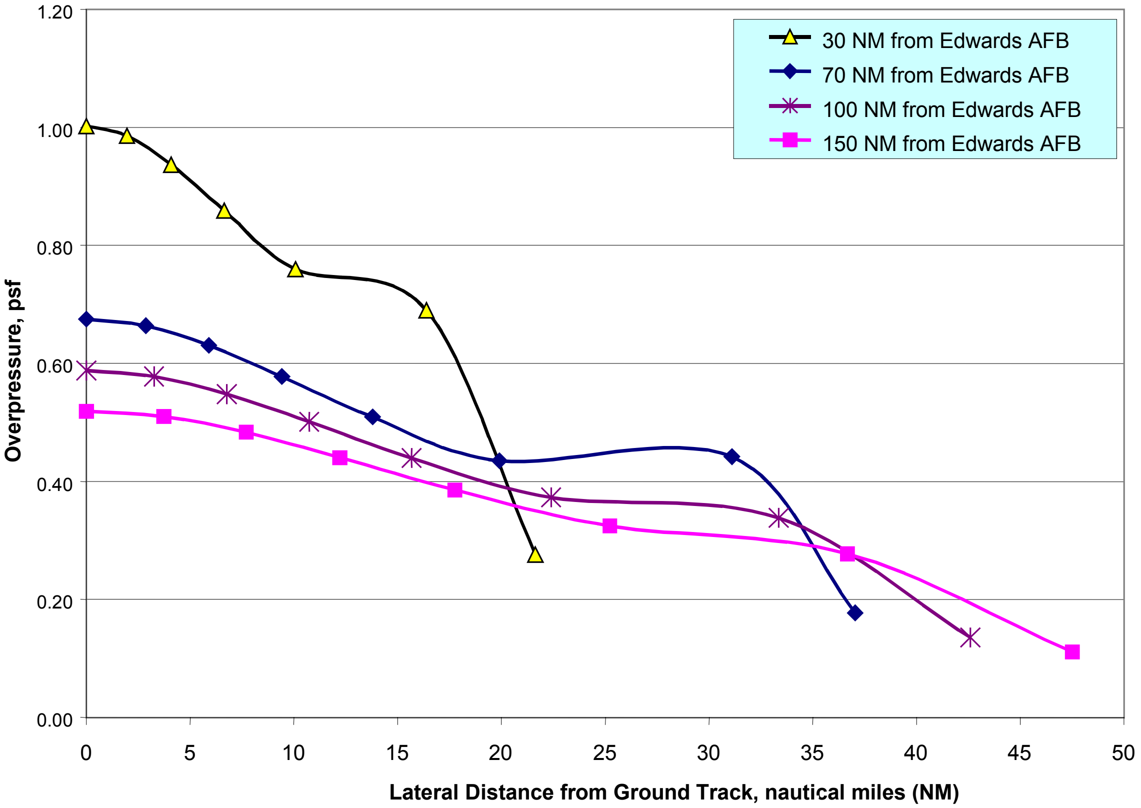


Figure 4-5 Relationship Between Estimated Sonic Boom Overpressures and Lateral Cutoff Distances for the Proposed Project

4.10.1 Alternative A (Western Approach)

4.10.1.1 On-Base Region

The unmanned LEV will be intercepting the landing heading alignment circle over Edwards AFB about Mach 1 above 40,000 feet msl. Sonic booms will occur over the Edwards AFB complex, but are predicted to be less than the Space Shuttle orbiter and no significant impact is expected. Sonic booms are a normal occurrence at this flight test site.

4.10.1.2 Off-Base Region

Sonic booms generated from the unmanned LEV would only have a slight chance of damaging windows, plaster, and bric-a-brac in structures within 17 and 30 nautical miles (20 and 35 statute miles) of Edwards AFB. The probability of glass breakage, however, would be between 1 and 23 window panes in 1 million panes. Due to the low probability of damage to structures, impacts to structures from sonic boom noise are not anticipated.

Ten daytime sonic booms of 1 pound per square foot or one nighttime sonic boom of 1 pound per square foot every day for a year would result in a CDNL of 61 dBC. Similarly, 12 unmanned LEV landings per year with 6 daytime landings and 6 nighttime landings would result in a CDNL of less than 48 dBC. Because predicted CDNL levels would be less than the 61 dBC threshold for the unmanned LEV, there would be no long-term annoyance noise impacts to the human population and no conflicts with land use compatibility. In addition, predicted noise levels from the unmanned LEV would be almost half of those generated from the Space Shuttle. Edwards AFB and DFRC have had minimal environmental problems associated with sonic boom noise from the Space Shuttle as it relates to communities, population concentrations, or the public in general.

Sonic boom overpressure levels of 1 pound per square foot correspond with a CSEL of 100.4 dB. These decibel levels would be experienced for approximately 1 second during the sonic boom within 17 and 30 nautical miles (20 and 35 statute miles) of Edwards AFB. The minimum sonic boom overpressure levels of approximately 0.2 pound per square foot correspond with a CSEL of 85.4 dB. These decibel levels would be experienced for approximately 1 second during the sonic boom as far out as 1,000 nautical miles (1,176 statute miles) from Edwards AFB. Because these CSEL levels are above 61 dBC, the acceptable threshold for ambient conditions, sonic boom noise could elicit a short-term startle response in humans and wildlife (see Section 4.9 above). However, because these noise levels would be significantly less than those experienced by the Space Shuttle, and would occur infrequently over the course of a year, these short-term noise impacts would be less than significant.

4.10.2 Alternative B (Northwestern Approach)

4.10.2.1 On-Base Region

The on-base noise impacts generated from Alternative B would be identical to those described under Alternative A.

4.10.2.2 Off-Base Region

Off-base noise impacts under Alternative B would be identical to those described under Alternative A.

4.10.3 Alternative C (No-Action)

Under the No-Action Alternative, the orbital reentry corridor would not be established, therefore, no on- or off-base noise impacts would occur.

4.11 PUBLIC/EMERGENCY SERVICES

An impact to public/emergency services would be considered significant if it resulted in slower response times by fire protection services, security services, or medical services or failure of these services.

4.11.1 Alternative A (Western Approach)

Under normal reentry and landing procedures, Alternative A would not require the use of any additional on- or off-base public or emergency services, including firefighters, security, or medical services.

The breakup of the unmanned LEV during a crash and subsequent recovery activities would require the use of public and emergency services, including firefighters, security, and medical services. The best estimate of the probability of failure during descent of the unmanned LEV was determined to be 3 in

1,000 (see Appendix A). Because the probability of a crash is low, additional public/emergency services would not be necessary for reentry and landing of the LEV.

4.11.2 Alternative B (Northwestern Approach)

Impacts to public/emergency services generated under Alternative B would be identical to those described under Alternative A.

4.11.3 Alternative C (No-Action)

Under the No-Action Alternative, the orbital reentry corridor would not be created, therefore, no impacts to public/emergency services would occur.

4.12 SAFETY

A safety impact would be considered significant if it created a potential public health hazard, or involved the use, production, or disposal of materials that pose a hazard to people.

4.12.1 Alternative A (Western Approach)

The DFRC's Hazardous Communication Program and Institutional Safety and Occupational Health programs would be followed to reduce the potential for any risk to health and safety from Orbital Reentry Corridor Program activities. Because construction of new facilities, including facilities emitting EMR or lasers, would not be required for the program, impacts to on-base health and safety under normal conditions would not occur.

In the event of an accident, NASA DFRC would be required to comply with Occupational Safety and Health and Administration regulations and DFRC's Emergency Response Plan. The breakup of the unmanned LEV during a crash could cause casualties and loss of property. The best estimate of the probability of failure during descent of the unmanned LEV was determined to be 3 in 1,000 (see Appendix A). In comparison, the risk of being involved in a commercial aircraft accident where there are multiple fatalities is approximately 1 in 3 million flights (About 2002).

4.12.2 Alternative B (Northwestern Approach)

Impacts would be similar under Alternative B as impacts under Alternative A. However, because the corridor under Alternative B is larger, there is a greater risk of casualty and loss of property during a crash under Alternative B.

4.12.3 Alternative C (No-Action Alternative)

Under the No-Action Alternative, the orbital reentry corridor would not be established, therefore, no impacts to safety would occur.

4.13 SOCIOECONOMICS

Socioeconomic impacts would be considered significant if they substantially altered the location and distribution of the population within the region of influence; caused the population to exceed historic growth rates; decreased jobs so as to substantially raise the regional unemployment rates or reduce income generation; substantially affected the local housing market and vacancy rates; or resulted in the need for new social services and support facilities.

4.13.1 Alternative A (Western Approach)

Since no new development would be required under the Orbital Reentry Corridor Program and current Air Force or contractor personnel from other bases would be used for the program, Alternative A would not impact the socioeconomics of on- or off-base populations.

4.13.2 Alternative B (Northwestern Approach)

Socioeconomic impacts generated under Alternative B would be identical to those described for Alternative A.

4.13.3 Alternative C (No-Action Alternative)

Under the No-Action Alternative, the Orbital Reentry Corridor Program would not be implemented, therefore, no socioeconomic impacts would occur.

4.14 WATER RESOURCES

A project would have a significant impact on water resources if it caused substantial flooding or erosion; substantially affected any significant water body, such as an ocean, stream, lake, or bay; exposed people to reasonably foreseeable hydrologic hazards such as flooding or tsunamis; or substantially affected surface or groundwater quality or quantity.

4.14.1 Alternative A (Western Approach)

4.14.1.1 On-Base Region

Alternative A would use either concrete Runway 22 or the Rogers Dry Lakebed for landing. No construction activities would be required since both locations are routinely used for landing other aircraft. Rogers Dry Lake does flood during heavy rain events, but, because the LEV would not land when the lakebed is flooded and landings on Rogers Dry Lakebed are a routine activity, landing the unmanned LEV on the lakebed is not anticipated to affect water resources on-base.

The breakup of the unmanned LEV during a crash and subsequent recovery activities could directly impact water resources on base through ground disturbance. The best estimate of the probability of failure during descent of the unmanned LEV was determined to be 3 in 1,000 (see Appendix A). If the unmanned LEV were to crash, it would either crash intact or break into its seven components. The probability of hitting specific assets on the ground is comparable to the probability of casualty to humans which is estimated to be less than 5 in 1 million missions (see Appendix A). Because the probability of a crash is low, impacts to on-base water resources as a result of a crash are not anticipated.

4.14.1.2 Off-Base Region

The breakup of the unmanned LEV during a crash and subsequent recovery activities could directly impact off-base water resources through ground disturbance. The best estimate of the probability of failure during descent of the unmanned LEV was determined to 3 in 1,000 (see Appendix A). Because the probability of a crash is low, impacts to off-base water resources as a result of a crash are not anticipated.

4.14.2 Alternative B (Northwestern Approach)

4.14.2.1 On-Base Region

Impacts to water resources generated by Alternative B are expected to be identical to those for Alternative A.

4.14.2.2 Off-Base Region

As under Alternative B, the breakup of the unmanned LEV during a crash and subsequent recovery activities could directly impact off-base water resources through ground disturbance. The best estimate of the probability of failure during descent of the unmanned LEV was determined to be 3 in 1,000 (see Appendix A). If the unmanned LEV were to crash, it would either crash intact or break into its seven components. The probability of hitting specific assets on the ground is comparable to the probability of casualty to humans which is estimated to be less than 5 in 1 million missions (see Appendix A). Because the probability of a crash is low, impacts to off-base water resources as a result of a crash are not anticipated.

4.14.3 Alternative C (No-Action)

Under the No-Action Alternative, the Orbital Reentry Corridor Program would not be implemented, therefore, there would be no impacts to water resources.

4.15 CUMULATIVE IMPACTS

Cumulative impacts refer to two or more individual impacts that, when considered together, are significant or that compound or increase other environmental impacts. The cumulative impact of several projects is the change in the environment that results from the incremental impact of the project when added to other closely related past, present, or reasonably foreseeable future projects. Cumulative impacts can result from individually minor but collectively significant projects taking place over a period of time.

4.15.1 Alternative A (Western Approach)

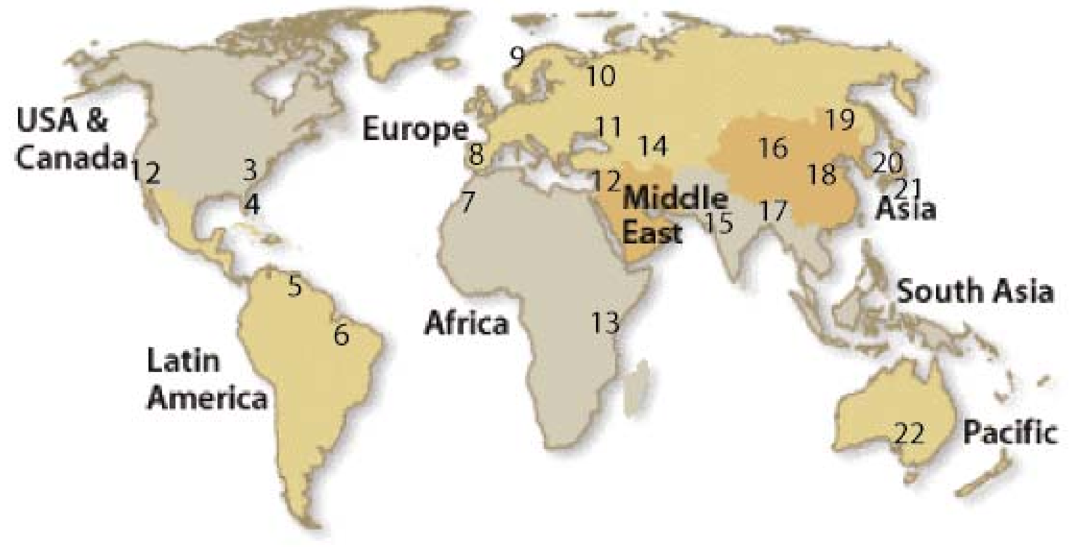
4.15.1.1 Airspace and Land Use

One unmanned LEV landing in 2004, two per year in 2005 and 2006, five per year in 2007 and 2008, and twelve per year beginning in 2009 would not be of a volume or magnitude that would cumulatively be significant for resources in the area. In 2000, a total of 11,168 landings occurred at Runway 22. Rogers Dry Lake has been used as a landing site for Space Shuttle tests and operational flights and other emergency and test landings of aircraft since 1977. Considered individually, the environmental impacts associated with the orbital reentry and landing of an unmanned LEV would be minimal.

Space Launch Sites and Launch Vehicles

It will be the responsibility of the sponsoring agency and the manufacturer of the unmanned LEV to evaluate the environmental effects of the proposed launch phase of the program based on the specific launch sites and launch vehicle used to place the unmanned LEV into low earth orbit. As such, this EA does not evaluate the potential launch sites or launch vehicles, which would be an integral part of an unmanned LEV program.

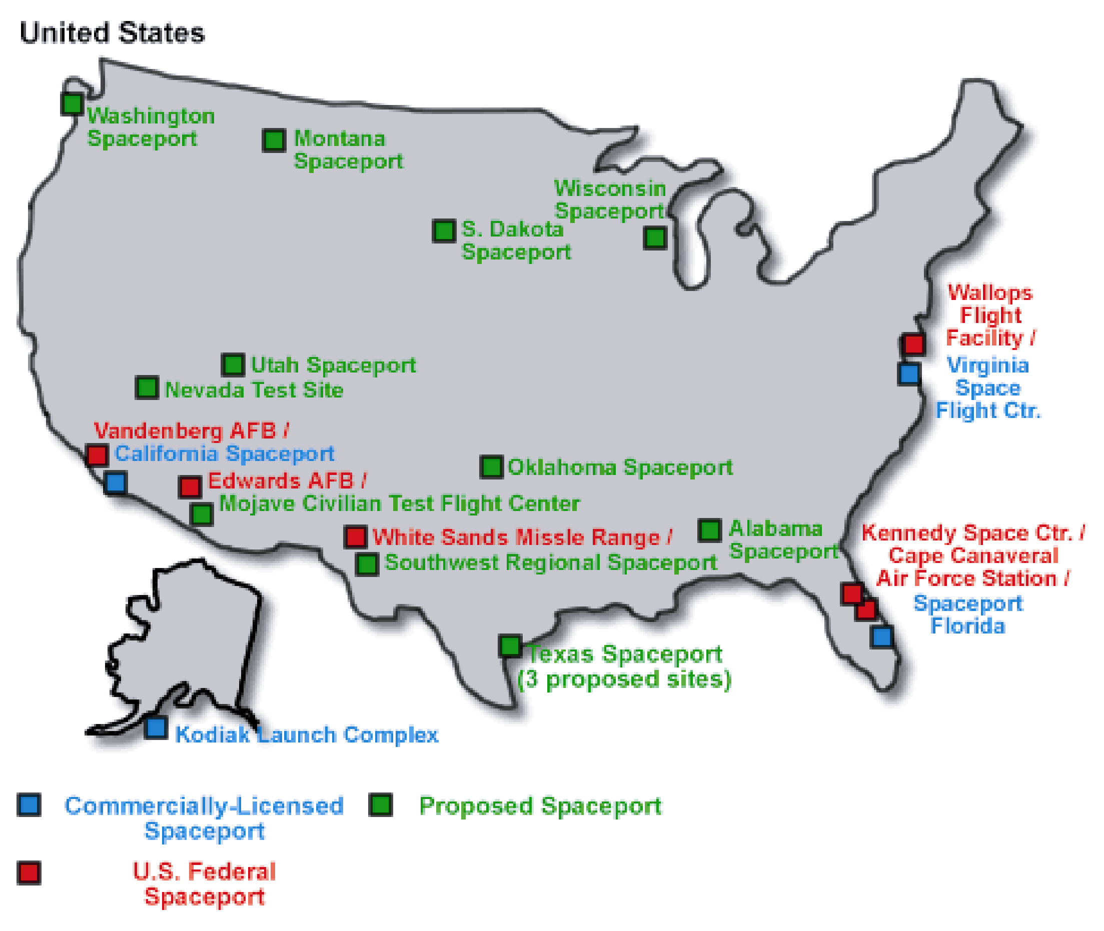
Launch sites for this type of vehicle are typically referred to as spaceports. Fewer than two dozen spaceports have been constructed. Some of these sites are well known while others are secret military sites. The busiest spaceports are Cape Canaveral, Florida, United States; Vandenberg AFB, California, United States; Baikonur, Russia; Plesetsk, Russia; Kourou, French Guiana; Tanegashima, Japan; Jiuquan, China; Xichang, China; and Sriharikota, India. Depending on the political realities and technical requirements, an unmanned LEV could be launched from one of these spaceports or one of the other military sites capable of launching payloads in excess of 13,636 kilograms (30,000 pounds). Figure 4-6 shows the locations of the primary international spaceports and Figure 4-7 shows the locations of current and proposed U.S. spaceports.



1 - Vandenberg AFB
2 - Edwards AFB
3 - Wallops Island
4 - Cape Canaveral
5 - Kourou
6 - Alcantara
7 - Hammaguir
8 - Torrejon
9 - Andoya
10 - Plesetsk
11 - Kapustin Yar
12 - Palmachim
13 - San Marco
14 - Baikonur
15 - Sriharikota
16 - Jiuquan
17 - Xichang
18 - Taiyuan
19 - Svobodny
20 - Kagoshima
21 - Tanegashima
22 - Woomera

Source: Space Today 2002.

Figure 4-6 Primary International Spaceports


United States
Washington Spaceport
Montana Spaceport
Wisconsin Spaceport
S. Dakota Spaceport
Wallops Flight Facility /
Virginia Space Flight Ctr.
Utah Spaceport
Nevada Test Site
Vandenberg AFB /
California Spaceport
Oklahoma Spaceport
Edwards AFB /
Mojave Civilian Test Flight Center
White Sands Missle Range /
Southwest Regional Spaceport
Alabama Spaceport
Kennedy Space Ctr. / Cape Canaveral Air Force Station /
Spaceport Florida
Texas Spaceport (3 proposed sites)
Kodiak Launch Complex
🟦 Commercially-Licensed Spaceport
🟩 Proposed Spaceport
🟥 U.S. Federal Spaceport

Source: Federal Aviation Administration 2002b.

Figure 4-7 Current and Proposed Launch Sites in the United States

Since 1957, over 5,000 satellites and space vehicles have been boosted into orbit. This rate is expected to increase by 70 to 80 launches per year as competing nations and commercial enterprises launch their payloads. Most of these launches are projected to be in support of light to medium weight payloads (less than 5,400 kilograms, or 11,800 pounds). Currently there are less than 20 launch vehicles, as identified in Table 4-2, that are capable of placing the unmanned LEV into low earth orbit.

Table 4-2
Potential Launch Vehicles for Unmanned LEV

Launch Vehicle	Country	Payload Weight to Low Earth Orbit	
		kilograms	pounds
Titan III/TOS	USA	14,515	31,933
Titan IV/Centaur	USA	18,144	39,917
Titan IV/SRM/Centaur	USA	18,144	39,917
Titan IV/SRM/IUS	USA	23,350	51,370
Delta IV Heavy	USA	22,727	50,000
Atlas V - 2 Solid	USA	17,273	38,000
STS (Space Shuttle)	USA	27,727	61,000
Ariane 5	Europe	18,000	39,600
Energia EUS	Russia	88,000	193,600
Energia EUS/RCS	Russia	88,000	193,600
H IIA LRB	Japan	14,000	30,800
Proton D-1-e	Russia	20,000	44,000
Proton D-1-e Star 27	Russia	20,000	44,000
Proton D-1-e Star 48B	Russia	20,000	44,000
Proton K	Russia	20,900	45,980
Proton M	Russia	22,500	49,500
Zenit 2	Russia	13,740	30,228

Based on the projected recovery of unmanned LEVs for this program, the cumulative impact on projected launches is expected to be less than 1 percent each year from 2004 through 2008 and less than 5 percent for the remainder of the program.

4.15.1.2 Noise

The DFRC aircraft that generate sonic booms under existing operations are the F-15, F-16, F-18, and SR-71 during high-speed (Mach 2.0 to 3.0 [1,522 to 2,284 mph]) flights. Sonic boom experiments carried out in the R-2508 Complex, using the SR-71, were completed in 1995. The measurements show that at high altitudes (approximately 65,000 to 80,000 feet), high speed sonic boom overpressures propagated by the SR-71 are less than 1.0 pounds per square foot at ground level. These experimental results generally fit into the established pattern of other available sonic boom data from F-104, F-106, B-58, and XB-70 supersonic aircraft experiments. The results of these experiments have established that sonic boom overpressures in this range do not result in adverse impacts. Therefore, cumulative noise impacts are not anticipated under the Orbital Reentry Corridor Program.

4.15.2 Alternative B (Northwestern Approach)

Cumulative impacts generated by Alternative B would be identical to those described for Alternative A.

4.15.3 Alternative C (No-Action)

Under the No-Action Alternative, the Orbital Reentry Corridor Program would not be implemented, therefore, cumulative impacts would not occur.

4.16 UNAVOIDABLE ADVERSE IMPACTS

Unavoidable adverse impacts include those that are negative, occurring regardless of any identified minimization measures. A crash of the LEV would result in unavoidable adverse impacts. However, due to the low probability of a crash, establishment of the Alternative A (Western Approach) corridor or Alternative B (Northwestern Approach) corridor would not result in any unavoidable adverse impacts.

4.17 SHORT-TERM VERSUS LONG-TERM PRODUCTIVITY OF THE ENVIRONMENT

Short-term uses of the environment include direct, construction-related disturbances and direct impacts associated with an increase in population and activity that occurs over a period typically less than 5 years. Long-term uses of the environment include impacts occurring over a period of more than 5 years, including permanent resource loss.

Since no new development would be required under the Orbital Reentry Corridor Program and current Air Force or contractor personnel from other bases would be used for the program, neither Alternative A nor B would involve any short- or long-term changes in population or productivity of the environment.

4.18 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

Irreversible and irretrievable resource commitments are related to the use of nonrenewable natural resources and the effects that the use of those resources will have on future generations. Irreversible effects primarily result from the use or destruction of a specific resource (e.g., energy and minerals) that cannot be replaced within a reasonable time frame. Irretrievable resource commitments involve the loss in value of an affected resource that cannot be restored as a result of implementing an action (e.g., extinction of a rare or threatened species, or the disturbance of an important cultural resource site). In accordance with NEPA (40 CFR 1502.16), this section includes a discussion of any irreversible and irretrievable commitment of resources associated with the proposed project.

This EA only addresses reentry and landing of an unmanned LEV. Reentry and landing of an unmanned LEV within the Alternative A (Western Approach) corridor, or the Alternative B (Northwestern Approach) corridor would not require an irreversible or irretrievable commitment of resources. Irreversible or irretrievable commitment of resources that would be involved in other phases of the program (e.g., vehicle fabrication, launch, refurbishment, flights with specific payloads) would be addressed in separate environmental documentation. Implementation of Alternative C (No-Action Alternative) would also not require an irreversible or irretrievable commitment of resources.

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5.0 COMPLIANCE WITH APPLICABLE ENVIRONMENTAL REQUIREMENTS

This section provides a description of the federal, state, local, and Air Force regulations with which Edwards AFB must comply, including a description of the permits, licenses, and entitlements required, prior to and during planning and operation of the Proposed Action and Alternatives.

5.1 PERMITS, LICENSES, AND ENTITLEMENTS

The AFFTC Access-to-Space Office, AFFTC Environmental Management Office (AFFTC/EMXC), NASA DFRC, and AFFTC Flight Safety Office will work together to apply for or seek to modify various permits or licenses in accordance with federal, state, or local regulatory requirements for the proposed project. FAA licensing requirements may be necessary as described below.

5.1.1 Commercial Vehicle Licensing Requirements

Each reentry of a commercial vehicle requires a site license that has been evaluated and approved by the FAA in accordance with the guidelines established by the Commercial Space Transportation Reusable Launch Vehicle and Reentry Licensing Regulations (Title 14 CFR Parts 431 and 433).

5.1.2 Mission-Specific License

A mission-specific license authorizing an RLV mission authorizes a licensee to launch and reenter, or otherwise land, one model or type of RLV from a launch site approved for the mission to a reentry site or other location approved for the mission. A mission-specific license authorizing an RLV mission may authorize more than one RLV mission and identifies each flight of an RLV authorized under the license. A licensee's authorization to conduct RLV missions terminates upon completion of all activities authorized by the license or the expiration date stated in the license, whichever comes first.

5.1.3 Operator License

An operator license for RLV missions authorizes a licensee to launch and reenter, or otherwise land, any of a designated family of RLVs, within authorized parameters, including launch site and trajectories, transporting specified classes of payloads to any reentry site or other location designated in the license. An operator license for RLV missions is valid for a 2-year, renewable term.

5.1.4 License to Operate a Reentry Site

The FAA issues licenses to operate a reentry site when it determines that an applicant's operation of the reentry site does not jeopardize public health and safety, the safety of property, United States national security or foreign policy interest, or international obligations of the United States. A license to operate a reentry site authorizes the licensee to offer use of the site to support reentry for which a three-sigma footprint of the vehicle upon reentry is wholly contained within the site.

5.1.5 Government Vehicle Licensing Requirements

There are no specific licenses required for government vehicles (Young 2001). Guidance for safety responsibilities is established under DoD Directive 3200.11. Those responsibilities include ensuring safety is consistent with operational requirements. For earth recovery or impact of orbiting space vehicles, the safety responsibility rests with the activity controlling the recovery portion of the flight. Specifically, the controlling activity must:

- Determine policies and enforce safety procedures.
- Coordinate safety plans and procedures with other agencies within potentially affected areas and issue notices within the United States and to foreign governments on anticipated hazards from test activities.
- Coordinate on public affairs plans and assist in disseminating appropriate information.
- Establish allowable ground and flight safety conditions and take appropriate action to ensure the test articles do not violate the conditions.
- Notify the National Military Command Center if an accident or errant trajectory occurs that may have international implications.

The responsible installation commander will require the local safety review board recommendations before giving approval. There must also be coordination among the range where the vehicle will be landing, the FAA, and any other civil entities that will be affected.

5.2 REGULATIONS

5.2.1 Air Quality

Federal Regulations

- The 1970 *Federal Clean Air Act* (CAA), and the 1990 *Clean Air Act Amendments*, regulate air pollution emissions from stationary and mobile sources to protect public health and welfare. Air quality regulations were first promulgated with the CAA and revised with the amendments. Stationary sources at Edwards AFB typically include fixed sources such as internal combustion engine generators, external combustion boilers, and spray paint booths. Mobile sources typically include motor vehicles, construction equipment, and aircraft.

5.2.2 Airspace

Federal Regulations

- *The Federal Aviation Act* establishes the operations and responsibilities within the FAA's jurisdiction.
- *Federal Aviation Regulation Part 73, Special Use Airspace*, designates restricted areas and prescribes limitations on the operation of aircraft within them.
- *Federal Aviation Regulation Part 77, Objects Affecting Navigable Airspace,* establishes standards for determining obstructions in navigable airspace, sets for requirements for notice of certain proposed construction/alteration projects, provides for aeronautical studies of obstructions to air navigation, and provides for public hearings on the hazardous effect of proposed construction/alteration projects.

- *Federal Aviation Regulation 91, General Operating and Flight Rules,* prescribes rules governing the operation of aircraft within the United States, including the waters within 3 nautical miles of a United States coast.

- *Federal Aviation Regulation Part 93, Special Air Traffic Rules and Airport Traffic Patterns,* prescribes special airport traffic patterns and airport traffic areas. It also prescribes special air traffic rules for operating aircraft in those traffic patterns and traffic areas and in the vicinity of airports.

- *Federal Aviation Administration Order 7110.65, Air Traffic Control,* prescribes air traffic control procedures and phraseology for use by persons providing air traffic control services.

Air Force Directives and Instructions

- *Air Force Policy Directive 13-2, Air Traffic Control Airspace, Airfield, and Range Management,* establishes policies to sustain a flying environment that promotes safety and permits realistic training. This Directive encourages that environment by providing policies to govern the use of airspace, training weapons ranges, and support facilities and equipment.

- *Air Force Instruction 11-201, Flight Information Publications,* implements Air Force Policy Directive *11-2, Aircraft Rules and Procedures.* This Instruction prescribes the process for submitting Air Force operational requirements to obtain new or modified Flight Information Publications products, additional flight information, or other displays of flight information data in Flight Information Publications products. It does not include instrument procedure requirement changes.

- *Air Force Instruction 11-401, Flight Management,* sets procedures for managing Air Force flying resources and gives guidance that applies to administering flight management, aircrew training, and aircrew evaluation programs. It applies to all Air Force flight managers, commanders of flying units, and aircrew personnel.

- *Air Force Instruction 13-201, Air Force Airspace Management,* prescribes responsibilities and procedures for developing, coordinating, and managing special-use airspace and airspace for special use in the National Airspace System.

- *Air Force Instruction 13-203, Air Traffic Control,* directs the management of air traffic systems, personnel, and facilities. It directs the training of air traffic controllers and automation specialists, the administration of facilities, the use of equipment, and the operation of control towers and air traffic control radar facilities.

- *Air Force Instruction 13-213, Airfield Management,* applies to all organizations that operate or administer functions and facilities for military airfield management.

- *Air Force Manual 11-230, Instrument Procedures,* provides guidance on establishing, approving, revising, or deleting instrument procedures. It applies to flying activities at all airfields where the Air Force, or an Air Force component of a unified command, conducts or supports instrument flight.

- *Air Force Flight Test Center Instruction 11-1, Aircrew Operations,* sets the policies and defines procedures for aircrews operating aircraft at Edwards AFB.

- *Air Force Flight Test Center Instruction 11-2, Ground Agency Operations,* sets policies and procedures for all ground agencies supporting aircraft operations at Edwards AFB.

- *Air Force Flight Test Center Instruction 11-15, Scheduling Procedures for Aircraft and Air/Ground Support,* establishes procedures for scheduling aircraft, air/ground support, and/or resources at Edwards AFB. It prescribes policies and functional responsibilities and applies to all personnel authorized to use AFFTC resources.

5.2.3 Cultural Resources

Federal Regulations

- The *National Historic Preservation Act* (NHPA) of 1966, as amended (16 U.S.C. 470 *et seq*.), provides for the establishment of the National Register and authorized the establishment of criteria to determine the eligibility of cultural sites for listing on the National Register. Section 106 of the NHPA requires federal agencies to evaluate the effects of their activities and programs on eligible cultural resources (which include prehistoric and historic archaeological resources, historic resources, and traditional cultural places). Section 110 of the NHPA directs federal agencies to undertake actions necessary to minimize harm to cultural resources under their ownership or control, or affected by their activities and programs.

- The *Archaeological and Historic Preservation Act of 1974* requires all agencies to report to the Secretary of the Interior if any of their projects may cause the loss of "significant scientific, prehistoric, historic, or archaeological data;" it gives them the choice of recovering threatened data themselves or asking the Department of the Interior to do it for them; and it authorizes them to transfer up to 1 percent of the cost of the project to the Department of the Interior to support salvage.

- The *Federal Records Act* (44 U.S.C. 2101–2118, 2301–2308, 2501–2506, 2901–2909, 3101–3106, and 3301–3324) is a cultural resource law that covers all records including books, papers, maps, photographs, and machine readable and other documentary materials. Designed to preserve evidence of the government's organization, policies, decisions, operations, and activities and basic historical information, violation of the *Federal Records Act* is punishable by fines and jail sentences.

Air Force Directives and Instructions

- Air Force Instruction 32-7065, *Cultural Resources Management*, at Edwards AFB is coordinated by the Base Historic Preservation Officer.

5.2.4 Hazardous Waste/Hazardous Materials

Federal Regulations

- The *Comprehensive Environmental Response Compensation and Liability Act* (CERCLA) (42 U.S.C. 9601) was enacted by Congress on December 11, 1980. This Act provides broad federal authority to respond directly to releases or threatened releases of hazardous substances that may endanger public health or the environment. The Act authorizes short-term removal actions and long-term remedial response actions. The Act establishes prohibitions and requirements concerning closed and abandoned hazardous waste sites; provides for liability of persons responsible for releases of hazardous waste at these sites; and establishes a trust fund to provide for cleanup on non-DoD property when no responsible party can be identified.

- *Federal Facilities Agreement* September 1990. The Federal Facilities Agreement requires compliance with the National Oil and Hazardous Substances Pollution Contingency Plan, CERCLA, RCRA, and applicable state laws. Under Section 6.2 of the Agreement, the Air Force agreed to undertake, seek adequate funding for, fully implement, and report on the following tasks: remedial investigation of sites; federal and state Natural Resource Trustee Notification and Coordination for the sites; feasibility studies for sites; all response actions for the sites; and operation and maintenance of response actions at the sites.

- *Executive Order 12580, Superfund Implementation*, delegates to various federal officials the responsibilities vested in the President for implementing CERCLA, as amended by SARA. This Order and the National Contingency Plan–the implementing regulations of CERCLA–are the basis of DoD's authority to implement CERCLA at their facilities. The Order delegates the authority and responsibility to DoD, while the National Contingency Plan describes the U.S. EPA's procedures for implementing the CERCLA program. The DoD is required to carry out a number of key functions, including providing representatives to the National Response Team, the interagency organization responsible for planning for and responding to CERCLA releases; acting as a natural resource trustee for land they manage; performing natural resource damage assessments; and assuming authority for response actions resulting from releases of hazardous substances on, over, or under land that they manage.

Air Force Directives and Instructions

- The following Air Force regulations must be upheld: Executive Order 12088, *Federal Compliance with Pollution Control Standards*; Air Force Instruction 32-4002, *Hazardous Material Emergency Planning and Response Program*; Air Force Instruction 32-7042, *Solid and Hazardous Waste Compliance*; Air Force Instruction 32-7080, *Pollution Prevention Program*; Air Force Instruction 32-7086, *Hazardous Materials Management*; AFFTC Instruction 23-1, *Hazardous Material Management Program*; AFFTC Instruction 32-19, *Hazardous Material Management Process; Edwards Air Force Base Hazardous Waste Management Plan; AFFTC Oil and Hazardous Substance Spill Prevention and Response Plan* (AFFTC 1993); and the Explosives Ordnance Disposal memorandum.

State Regulations

- The following state laws must also be upheld: California Hazardous Waste Control Law (California Safety and Health Code 25100–25250.25 [22 CCR 66001–67800.51]); State Hazardous Materials Release Response Plans and Inventory Law (Assembly Bill 2185, Chapter 6.95 of the Health and Safety Code); California Hazardous Substances Act (California Health and Safety Code Section 28740 *et seq.*); and Hazardous Substances

Highway Spill Containment and Abatement Act (California Vehicle Code Section 2450 *et seq*.).

5.2.5 Infrastructure

Federal Regulations

- *Executive Order 13123, Greening of the Government through Efficient Energy Management,* identifies the DOE as the lead agency responsible for implementing the act and establishes seven goals regarding energy use that are applicable to federal agencies. These goals target reduction of:
    - Greenhouse gases;
    - Petroleum use;
    - Energy use by industrial, laboratory, and other facilities;
    - Total energy use (as measured at the source);
    - Water consumption (and associated energy use); and
    - Expanded use of renewable energy is also targeted.

Air Force Directives and Instructions

- Air Force Instruction 23-201, *Fuels Management*, establishes policies and procedures for fuel operations. It applies to all Air Force activities, including U.S. Air Force Reserve and Air National Guard units that receive, store, and issue fuel, perform quality control, and account for aviation fuels, ground fuels, cryogenic fluids, and missile propellants.

- Air Force Policy Directive 23-3, *Energy Management,* establishes policies for responsibly allocating, controlling, and using energy. These include eliminating waste and conserving energy resources, eliminating energy disruptions to missions and facilities, promoting vehicles energy efficiency, and increasing utility energy efficiency through capital investment and improvement operations.

- The objective of the *Air Force Materiel Command Energy Management* Program is to reduce energy consumption. Eight initiatives are used to measure a base's performance relative to achieving this goal. They include program direction, cost reduction, facility operation, product procurement, capital investment, human resources, public awareness, and environmental interface (AFFTC 1995).

- *The Edwards Air Force Base Energy Plan* (AFFTC 1995) serves as a component of the Base Comprehensive Plan and documents the policies, direction of development, and specific projects associated with the base's desire to meet the national energy goals established by the *Energy Policy Act of 1992* (PL 102-486).

5.2.6 Land Use

Federal Regulations

- The *Federal Land Policy and Management Act* of 1976 (43 U.S.C. 1701 *et seq.*) establishes Congressional policy relating to the use and management of public lands.

- The *Wilderness Act* (16 U.S.C. 1131 *et seq.)*, enacted in 1964, establishes a National Wilderness Preservation System composed of federally owned areas to be administered for public use and enjoyment. These lands are to be left in their natural condition.

- The *Federal Aviation Act of 1958* (49 U.S.C. 1301 *et seq*.), establishes the operations and responsibilities within the FAA's jurisdiction.

Air Force Directives and Instructions

- Air Force Instruction 32-7063, *Air Installation Compatible Use Zone Program*, identifies the requirements to develop, implement, and maintain the AICUZ program. It applies to all Air Force installations with active runways located in the United States and its territories, including government-owned, contractor-operated facilities.

- Air Force Flight Test Center Instruction 10-2*, Control of Vehicles on the Airfield*, sets policies, procedures, and responsibilities for all agencies, including associates and contractors, that operate or support vehicles on the Edwards AFB flightline.

- Air Force Flight Test Center Instruction 11-2, *Ground Agency Operations*, sets policies and procedures for all ground agencies supporting aircraft operations at Edwards AFB.

- Air Force Flight Test Center Instruction 11-15, *Scheduling Procedures for Aircraft and Air/Ground Support*, establishes procedures for scheduling aircraft, air/ground support, and/or resources at Edwards AFB. It prescribes policies and functional responsibilities and applies to all personnel authorized to use AFFTC resources.

5.2.7 Natural Resources

Federal Regulations

- The *Endangered Species Act of 1973* (ESA) (16 U.S.C. 1531–1544) provides a framework for the protection of endangered and threatened species. Federal agencies may not jeopardize the existence of listed species, which includes ensuring that actions they authorize, fund, or carry out do not adversely affect the species or adversely modify designated critical habitats. Under the ESA, all federal departments and agencies also must utilize their authorities, as appropriate, to promote the recovery of listed species. In addition, the ESA prohibits all persons, including federal agencies, from harming or killing ("taking") individuals of a listed species without authorization. While federal agencies must consult with the U.S. Fish and Wildlife Service (USFWS) or National Marine Fisheries Service when their activities may affect listed species, projects cannot be stopped unilaterally by the services; however, for any anticipated "take" to be authorized, applicable measures to minimize the "take" that are developed in the consultation must be followed.

- Critical habitat is defined as the geographic area containing physical or biological features essential to the conservation of a listed species or an area that may require special management considerations or protection.

- The *Migratory Bird Treaty Act of 1918* (16 U.S.C. 703–712)*,* as amended, provides for federal protection of all migratory bird species, their active nests, eggs, etc. Permits are required to remove these birds from their roosting and nesting areas. The federal government is exempt from the Act's permit requirements based on the court decision in *Newton County Wildlife Assn. vs. U.S. Forest Service (1997),* but must minimize take caused by their activities. Non-federal contractors are required to obtain a depredation permit from the USFWS prior to removal or disturbance of nesting birds.

- The *Sikes Act* (16 U.S.C. 670a–670o)*,* as amended, provides for cooperation between the Departments of the Interior and Defense and state agencies in planning, development, and maintenance of fish and wildlife resources on military reservations throughout the United States.

- The *Coastal Zone Management Act of 1972* (16 U.S.C. 1451 *et seq*.) encourages states to preserve, protect, develop, and where possible, restore or enhance valuable natural coastal resources. A unique feature of the Coastal Zone Management Act is that participation by states is voluntary. To encourage states to participate, the act makes federal financial assistance available to any coastal state or territory, including those on the Great Lakes, that is willing to develop and implement a comprehensive coastal management program.

Air Force Directives and Instructions

- Department of Defense Directive 4700.4, *Natural Resources Management Program,* prescribes policies and procedures for an integrated management program of natural resources on DoD property. Enforcement of laws primarily aimed at protecting natural resources and recreation activities that depend on natural resources, is an integral part of a natural resources program and shall be coordinated with, or under the direction of, the natural resources manager for the affected area.

- Air Force Instruction 32-7064, *Integrated Natural Resources Management*, implements Air Force Policy Directive 32-70, *Environmental Quality*, and Department of Defense Directive 4700.4, *Natural Resources Management*. Air Force Instruction 32-7064 explains how to manage natural resources on Air Force property. The Integrated Natural Resources Management Plan is a key tool for managing the installation's natural resources.

State Regulations

- The *California Endangered Species Act* (CESA) (Fish and Game Code Section 2050 *et seq*.) generally parallels the main provisions of the federal ESA and is administered by the CDFG. Under the CESA, the term "endangered species" is defined as a species of plant, fish, or wildlife which is in serious danger of becoming extinct throughout all, or a significant portion of its range" and is limited to species native to California. The CESA establishes a petitioning process for the listing of state threatened or endangered species, and the CDFG is required to adopt regulations for this process. The CESA prohibits the taking of state-listed species except as otherwise provided in state law. Unlike the federal ESA, the CESA applies prohibitions to species petitioned for state listing (i.e., state candidates).

- The *Listing of Endangered and Threatened Species* (14 CCR 670) was drafted to provide a petition form and rules and procedures for the submission and review of petitions for listing, uplisting, downlisting, and delisting of state endangered and threatened species of plants and animals.

- The *California Fish and Game Code* contains the complete text of the legislated laws concerning fish and game. The CDFG is responsible for administering the legislated laws through enforcement of the requirements in the Fish and Game Code.

5.2.8 Public/Emergency Services

Federal Regulations

- Department of Defense Manual 5000.12H, *Force Protection*, establishes policies and procedures for effectively policing both people and property of the U.S. armed forces. This manual is a guideline for resource protection, as well as a tool that defines the role of security forces during emergencies/disasters.

Air Force Directives and Instructions

- Air Force Instruction 32-2001, *The Fire Protection Operations and Fire Prevention Program*, defines area responsibilities and establishes the process for implementing a fire protection and prevention program at every Air Force base.

- At Edwards AFB, Department of Defense Instruction *6055.6, DoD Fire and Emergency Services Program*, establishes parameters for the allocation, assignment, operation, and administration of DoD fire departments and related fire prevention functions, including emergency response. This instruction also establishes the DoD Fire and Emergency Services Quality Working Group; authorizes and monitors the publication of guides, handbooks, and manuals; and establishes the Department of Defense Fire Incident Reporting System.

- *Edwards AFB Fire Protection Program* was established as a means to prevent fire and reduce loss from fire/hazardous material incidents to the environment, personnel, and military property. The Program’s mission is accomplished by promoting aggressive fire prevention tactics, maintaining a community outreach program, and an expert fire-fighting and rescue force to protect the base. The 95th Civil Engineer Group, Fire Protection Division, is prepared to respond to emergencies (both on and off base) involving DoD facilities, structures, aircraft, equipment, hazardous materials, and natural/manmade disasters.

- Air Force Policy Directive 31-1, *Physical Security*, provides guidance to deter, detect, and defeat hostile acts against Air Force resources. In addition, it helps Air Force leaders make sound resource allocation decisions to achieve these goals.

- *Air Force Instruction 31-209, The Air Force Resource Protection Program*, gives the requirements for the Resource Protection Program and addresses the physical security of Air Force personnel, installations, operations, and assets.

5.2.9 Safety

Federal Regulations

- The Occupational Safety and Health Administration (OSHA) has developed standards to promote a safe working environment. The standards establish general environmental controls, including personal protective equipment, wherever necessary because of hazards, processes, or the environment. Exposure limits for noise, ionizing and non-ionizing radiation, and toxic and hazardous substances have been established, as well as requirements for handling and storing compressed gases and flammable liquids. The Administration also provides standards for emergency response to releases of hazardous chemicals and hazardous wastes.

- The *OSHA General Duty Clause, Section 5(a)1*, states that employers will provide a workplace free of recognized hazards that cause or are likely to cause death or serious physical harm.

- *Occupational Noise Exposure (Title 29 CFR 1910.95)* states that protection against the effects of noise exposure shall be provided when sound levels exceed those shown in this regulation.

- *American National Standards Institute Z136.1 – 1993, American National Standard for the Safe Use of Lasers*, provides guidance for the safe use of lasers and laser systems by defining control measures for each of four laser classifications. Once a laser or laser system is properly classified, there should be no need to carry out tedious measurements or calculations to meet the provisions of the standard. However, technical information on measurements, calculations, and biological effects is also provided within the standard and its appendices.

Air Force Directives and Instructions

- Air Force Policy Directive 91-2, *Safety Programs*, states that the Air Force is committed to providing safe, healthful environments both for its own personnel and for those affected by its operations. It must be alert to identify and control hazards and prevent mishaps. When mishaps do occur, the Air Force must learn the cause and take steps to ensure those mishaps are not repeated. This directive establishes policies for the Air Force's approach to safety.

  Statutory and regulatory requirements of the federal OSHA and the *Air Force Occupational Safety and Health Standards*, which apply to the safety of workers on Edwards AFB, are enforced locally by Bioenvironmental Engineering, Ground Safety, and the Base Fire Department. In addition, various offices for specific activities supervise operational safety.

- Air Force Instruction 91-202, *The U.S. Air Force Mishap Prevention Program*, implements Air Force Policy Directive 91-2, *Safety Programs*. It establishes mishap prevention program requirements, assigns responsibilities for program elements, and contains program management information. It applies to all Air Force personnel, including Air Force Reserve and Air National Guard members.

- Air Force Occupational Safety and Health Standard 48-9, *Radio Frequency Radiation Safety Program*, states that the criteria in this standard are the Air Force's minimum occupational health requirements. A program is established in this standard to prevent possible harmful effects to personnel from exposure to potentially hazardous levels of radio frequency radiation. This standard applies to all Air Force organizations, including all Air Force Reserve and Air National Guard on Federal Service. Major Commands supplement this standard when additional or more stringent safety and health criteria are required (refer to Air Force Instruction 91-301, *Air Force Occupational and Environmental Safety, Fire Protection, and Health (AFOSH) Program*, for instructions processing supplements or variances.

- Air Force Occupational Safety and Health Standard 48-10, *Laser Radiation Protection Program*, outlines how the Air Force will implement its Laser Radiation Protection Program. It assigns responsibilities for healthful and safe operations of laser systems and outlines the requirements of a proper protection program. The basic elements of the program imitate those of American National Standards Institute Z136.1.

- Air Force Occupational Safety and Health Standard 48-19*, Hazardous Noise Program*, provides the criteria for the Air Force's minimum occupational health requirements. A program is established in this standard to prevent possible harmful effects to personnel from exposure to hazardous noise. This standard applies to all Air Force organizations, including all Air Force Reserve units and members. It also applies to Air National Guard when published in the *National Guard Regulation* (AF) *0-2.* Major Commands supplement this standard when additional or more stringent safety and health criteria are required (as outlined in AFI 91-302*, Air Force Occupational and Environmental Safety, Fire Protection, and Health Standards*). This standard applies to all Air Force military and civilian personnel and to all sources of noise on Air Force facilities or under Air Force control. Contractor personnel are exempt.

- Air Force Flight Test Center Instruction 11-1, *Aircrew Operations*, provides policies and prescribes standard operational procedures for all aircrews assigned to or sponsored by Edwards AFB.

- Air Force Flight Test Center Instruction 11-2, *Ground Agency Operations*, applies to all ground agencies in support of aircraft operations at Edwards AFB.

5.2.10 Socioeconomics and Environmental Justice

Federal Regulations

- Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations,* requires federal agencies to identify and address disproportionately high adverse effects of its activities on minority and low-income populations.

Air Force Directives and Instructions

- Air Force Instruction 34-262, *Services Programs and Use Eligibility*, implements Air Force Policy Directive 34-2, Managing Nonappropriated Funds, by providing guidance on the scope and management of Services programs and eligibility of customers.

5.2.11 Aircraft Noise

Federal Regulations

- *The Aviation Safety and Noise Abatement Act of 1979* (49 U.S.C. 2101), grants authority to the Federal Aviation Administration to issue regulations on "air noise compatibility planning." Regulations are published in 14 CFR Part 150.

- Department of Defense Instruction 4165.57, *Air Installations Compatibility Use Zones (AICUZ)*, sets forth the Department of Defense policy on achieving compatible use of public and private lands in the vicinity of military airfields.

- Federal Management Circular 75-2, *Compatible Uses at Federal Airfields*, establishes authority for noise abatement and control.

- *The Noise Control Act* (42 U.S.C. 4901 et seq.) amends the *Federal Aviation Act* to specifically involve the EPA in the regulation of airport noise.

- *Air Installation Compatibility Use Zones (AICUZ) (Title 32 CFR Part 256),* requires the Secretaries of the military departments to develop, implement, and maintain a program to investigate and study all air installations and to analyze land use compatibility problems and potential solutions.

- *Airport Noise Compatibility Planning (Title 14 CFR Part 150)* promotes comprehensive noise evaluation and mitigation and is the primary program under which the FAA supports local airport noise compatibility planning and projects.

Air Force Directives and Instructions

- Air Force Instruction 13-201, *Air Force Airspace Management,* prescribes responsibilities and procedures for developing, coordinating, and managing special-use airspace and airspace for special use in the National Airspace System.

- Air Force Instruction 32-7063, *Air Installation Compatible Use Zone Program (AICUZ),* implements Air Force Policy Directive 32-70*, Environmental Quality*, by identifying the requirements to develop, implement, and maintain the AICUZ program. It also implements DoD Instruction 4165.57*, Air Installations Compatible Use Zones*, November 8, 1977.

- Air Force Handbook 32-7084*, AICUZ Program Manager's Guide,* provides specific guidance concerning the organizational tasks and procedures necessary to implement the AICUZ program, and summarizes the data collection steps and procedures for developing Air Force approved noise contours.

California Regulations

- *Noise Standards* (21 CCR 5000, *et. seq.)* provides noise standards governing the operation of aircraft and aircraft engines for all airports operating under a valid permit issued by the Department of Transportation. These regulations provide for the control and reduction of noise that impact areas in communities in the vicinity of airports.

5.2.12 Water Resources

Federal Regulations

- The *Clean Water Act* (33 U.S.C. 1251 *et seq.)*, as amended, is designed to restore and maintain the chemical, physical, and biological integrity of surface waters. The Act establishes effluent standards on an industry basis and addresses water pollution issues through a permitting system designed to control, and eventually eliminate, water pollution. The National Pollutant Discharge Elimination System is the principal federal regulatory mechanism used to control all source discharges of pollution into the water. Violations of the Clean Water Act can result in large fines and/or imprisonment.

- The *Wild and Scenic Rivers Act* (16 U.S.C. 1271 *et seq.*), enacted in 1968, serves to protect free-flowing rivers with outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values.

Air Force Directives and Instructions

- Air Force Instruction 32-1067, *Water Systems*, implements Air Force Policy Directive 32-10, *Installations and Facilities*; Air Force Policy Directive 32-70, *Environmental Quality*; and Department of Defense Directive 6230.1, *Safe Drinking Water*. It provides guidelines for managing drinking water and wastewater systems at Air Force bases.

- Air Force Instruction 32-7041, *Water Quality Compliance*, provides details of the Air Force Water Quality Compliance Program. It applies to generating, collecting, treating, reusing, and disposing of domestic and industrial wastewater, storm water, nonpoint-source runoff, sewage sludge, and water treatment residuals. It also explains how to assess, attain, and sustain compliance with the Clean Water Act; other federal, state, and local environmental regulations; and related DoD and Air Force directives.

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9.0 ACRONYMS AND ABBREVIATIONS

412 OG	412th Operations Group
412 TW	412th Test Wing
95 ABW	95th Air Base Wing
AFB	Air Force Base
AFFTC	U.S. Air Force Flight Test Center
AFOSH	Air Force Occupational Safety and Health
AFRL	Air Force Research Lab
AGE	aerospace ground equipment
AGL	above ground level
AICUZ	air installation compatible use zone
ALT	approach and landing test
AOA	angle of attack
AOC	area of concern
APZ	accident potential zone
ARTCC	Air Route Traffic Control Center
ATC	air traffic control
AVEK	Antelope Valley East Kern
BLM	Bureau of Land Management
CAA	Clean Air Act
CAAQS	California Ambient Air Quality Standards
CAE	control area extension
Cal EPA	California Environmental Protection Agency
CARB	California Air Resources Board
CCR	California Code of Regulations
CDFG	California Department of Fish and Game
CDNL	C-weighted day-night level
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CESA	California Endangered Species Act
CFR	Code of Federal Regulations
CNEL	Community Noise Equivalent Level
CNPS	California Native Plant Society
CO	carbon monoxide
CSEL	C-weighted sound exposure level
dB	decibels
dBA	A-weighted decibels
dBC	C-weighted decibels
DFRC	Dryden Flight Research Center
DNL	day-night average noise level
DoD	Department of Defense
EA	Environmental Assessment
E_c	expectation of causality
E_f	expectation of fatality

EMR	electromagnetic radiation
ESA	Endangered Species Act
°F	degrees Fahrenheit
FAA	Federal Aviation Administration
FL	flight level
FONSI	Finding of No Significant Impact
FTS	flight termination system
GSE	ground support equipment
HAC	Heading Alignment Circle
HUD	Department of Housing and Urban Development
IFR	instrument flight rules
IRP	Installation Restoration Program
KCAPCD	Kern County Air Pollution Control District
L_{dn}	day/night average noise level
L_{eq}	long-term equivalent A-weighted sound level
LEV	lifting entry vehicle
LTO	landing and takeoff
MARSA	Military assumes responsibility for separation of aircraft
MDAB	Mojave Desert Air Basin
$\mu g/m^3$	micrograms per cubic meter
MOA	Military Operation Area
mph	miles per hour
msl	mean sea level
NAAQS	National Ambient Air Quality Standards
NACO	National Aeronautical Charting Office
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NO_x	nitrogen oxides
NO_2	nitrogen dioxide
NOTAM	Notice to Airmen
OSHA	Occupational Safety and Health Administration
OU	Operable Unit
PEL	permissible exposure limit
P_I	probability of aircraft impact
PL	Public Law
$PM_{2.5}$	particulate matter 2.5 microns or less in diameter
PM_{10}	particulate matter 10 microns or less in diameter
ppm	parts per million

PSD	Prevention of Significant Deterioration
QRA	Quantitative Risk Analysis
RCRA	Resource Conservation and Recovery Act
RLV	reusable launch vehicle
ROI	Region of Influence
SEA	Significant Ecological Area
SEL	sound exposure level
SIP	State Implementation Plan
SO_2	sulfur dioxide
SPL	sound pressure level
TCP	traditional cultural property
TRACON	Terminal Radar Approach Control
USACOE	U.S. Army Corps of Engineers
U.S.C.	United States Code
USDA	U.S. Department of Agriculture
U.S. EPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VFR	visual flight rules
VOC	volatile organic compound

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Final Quantitative Risk Analysis for Generic Unmanned Lifting Entry Vehicle Landing at Edwards Air Force Base

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ABBREVIATIONS AND ACRONYMS

AAAM	Association for the Advancement of Automotive Medicine
AFB	Air Force Base
AGL	Above Ground Level—a reference for altitude measurements in relation to the earth's surface
ARTCC	Air Route Traffic Control Center
ATADS	Air Traffic Data System
CRTF	Common Real-Time Footprint—a computer program used to calculate debris impact probabilities and expected casualties
E_C	Casualty expectation—expected number of casualties
E_F	Fatality expectation—expected number of fatalities
E_I	Impact expectation—expected number of fragment impacts on aircraft
ELV	Expendable Launch Vehicle
EWR	Eastern & Western Ranges (at Vandenberg AFB, CA and Patrick AFB, FL)
FAA	Federal Aviation Administration
HAC	Heading Alignment Circle—a maneuver to align the vehicle with the runway for landing
IAC	Instantaneous Airborne Count
LARA	Launch Risk Analysis—a computer program to compute debris risk from launch vehicles
LEV	Lifting Entry Vehicle
MSL	Mean Sea Level—a reference for altitude measurements from the earth's surface corrected for barometric pressure
NASA	National Aeronautics and Space Administration
NM	Nautical miles
OAMV	Office of Advanced Manned Vehicles
P_I	Probability of impact—the probability that one or more fragments will impact a location
RCC	Range Commanders Council
SAIC	Science Applications International Corporation

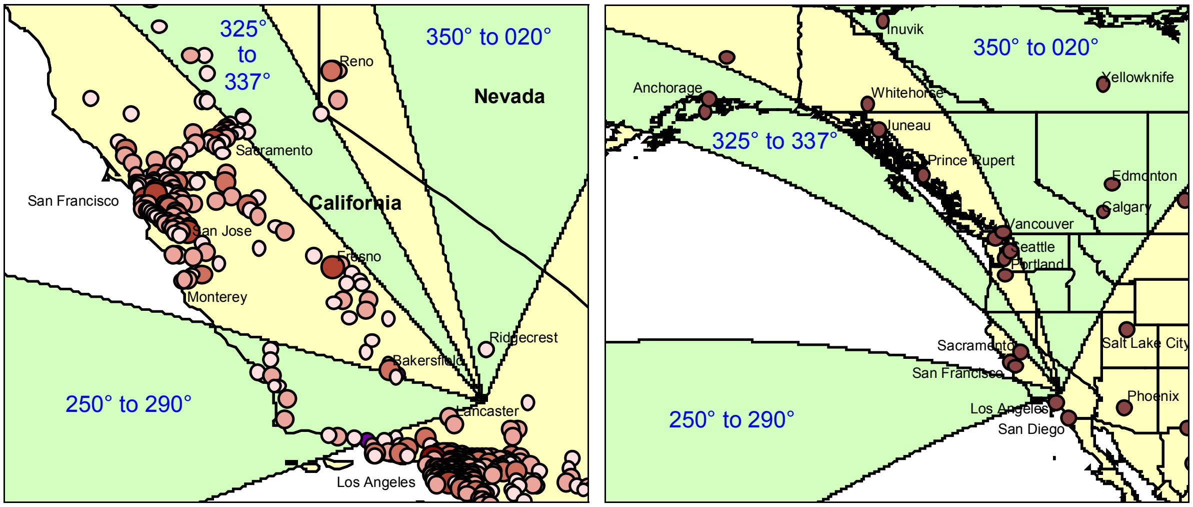
1.0 EXECUTIVE SUMMARY

This Quantitative Risk Analysis has been prepared to provide defensible evidence to support identification of generic high speed/altitude entry corridors for a medium-sized unmanned Lifting Entry Vehicle (LEV) to land at Edwards Air Force Base (AFB). By addressing the risks to persons and property the risk analysis will provide future customers with information that can be used in the environmental process for evaluating Edwards AFB as a landing site for flight test of unmanned LEVs.

The risk analysis was performed for a generic unmanned vehicle similar to past LEVs in order to evaluate various candidate trajectories. The best estimate for the probability of failure during descent was determined to be 3×10^{-3} (3 in 1,000)(section 3.2), although the risk was also analyzed for higher failure probabilities. The candidate trajectories were assumed to be along great circles until the vehicle began its heading alignment circle (HAC) maneuver to align with runway 22 at Edwards AFB.

The debris risk from vehicle malfunction was determined by the application of a debris footprint-based methodology. To determine the risk to the ground population, a model of population sheltering was developed based on census data from the western United States and Canada. To calculate aircraft risk, Federal Aviation Administration (FAA) data were used to create a model of aircraft density. The risk calculation allowed for uncertainties in fragment description, season (as it affects both the atmosphere and sheltering), trajectory information, and vehicle failure mode.

The computed risk was compared with two standards: the Range Commanders Council (RCC), which requires an expectation of fatality, E_F, less than 30×10^{-6} (30 fatalities per million missions) and the Range Safety Requirements of the Eastern and Western Ranges (EWR) which require an expectation of casualty, E_c, 30×10^{-6} (30 casualties per million missions). Following these standards, three corridors of trajectories are recommended for missions with failure probabilities less than one percent. These corridors are shown in Figure 1-1, one corridor to the west (azimuth from 250 to 290 degrees, an alternate corridor to the northwest (azimuth 325 to 337 degrees), and one corridor from polar orbits (azimuth from 350 to 020 degrees). Because the probability of aircraft impact, P_I , is less than the RCC standard of 1×10^{-7} (1 impact in 10 million missions) and EWR common practice of 1×10^{-8} (1 impact in 100 million missions), an aircraft exclusion zone for airspace outside Edwards AFB is not required (section 5.1).


325° to 337°
350° to 020°
Reno
Nevada
Sacramento
San Francisco
California
San Jose
Fresno
Monterey
Ridgecrest
Bakersfield
Lancaster
250° to 290°
Los Angeles
Inuvik
350° to 020°
Anchorage
Yellowknife
Whitehorse
Juneau
325° to 337°
Prince Rupert
Edmonton
Calgary
Vancouver
Seattle
Portland
Sacramento
Salt Lake City
San Francisco
Los Angeles
Phoenix
San Diego
250° to 290°

Note: Corridors shown in green; population shown by red points.

Figure 1-1 Maps of Recommended Corridors

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2.0 INTRODUCTION

This Quantitative Risk Analysis has been prepared to provide defensible evidence to support identification of generic high speed/altitude entry corridors for a medium-sized unmanned Lifting Entry Vehicle (LEV) to land at Edwards Air Force Base. By addressing the risks to persons and property, the risk analysis will provide future customers with information that can be used in the environmental process for evaluating Edwards AFB as a landing site for flight test of unmanned LEVs.

The major steps in completing the risk analysis were problem definition, characterization of assets at risk, and risk assessment.

> **Problem definition**. The risk analysis is intended to quantify risks for the return from orbit and descent of a generic LEV. To maximize the usefulness of this study it was desirable to keep the number of configuration/mission-specific assumptions to a minimum. This was accomplished through a combination of simplifying assumptions, parametric analyses, and inclusion of uncertainty in the analyses. All trajectories analyzed terminated at Edwards AFB.
>
> Chapter 3 provides a description of the vehicle assumptions, including breakup characteristics, estimated failure rates, and trajectory modeling.
>
> **Characterization of assets at risk.** Chapter 4 describes the methodology used to develop a population distribution and sheltering model based on census data for the western United States and Canada. Chapter 4 characterizes the use of Federal Aviation Administration (FAA) high-altitude flight data and landing data for airports to build a three-dimensional model of air traffic by aircraft type.
>
> **Risk assessment.** Chapters 4 and 5 describe the methodologies applied to assess the risk to ground populations and the risk to aircraft, respectively. These chapters also describe the application of a debris footprint-based risk analysis methodology (Baeker *et al.* 1977; Carbon and Collins 2001) to assessing the risks to ground-based populations and to aircraft.

Chapters 4 and 5 also include the results of the risk analysis. The risk to ground population is presented in Chapter 4, with the primary focus being on the differences in risk for trajectories at various azimuths. The sensitivity of the risk to other parameters is also explored, and the summary results are shown for different failure probabilities. The risk to other assets is not directly evaluated, however, contours of fragment impact probabilities are shown in Chapter 4, which can be used to evaluate the environmental risk to particular assets. The risk to aircraft, as a function of trajectory azimuth, is presented in Chapter 5.

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3.0 VEHICLE INFORMATION

The analysis was based on a generic LEV with the lifting body SV-5 shape as shown in Figure 3-1. The generic LEV was assumed to weigh 25,000 pounds during entry, and to be 30 feet long and 15.5 feet wide. A single reference trajectory spanning the time period from deorbit to approach to Edwards AFB was used as the basis for the risk analysis. As discussed in the section on vehicle trajectories, this trajectory was coupled to a shuttle-type-landing pattern to runway 22 at Edwards AFB by way of a Heading Alignment Circle (HAC).

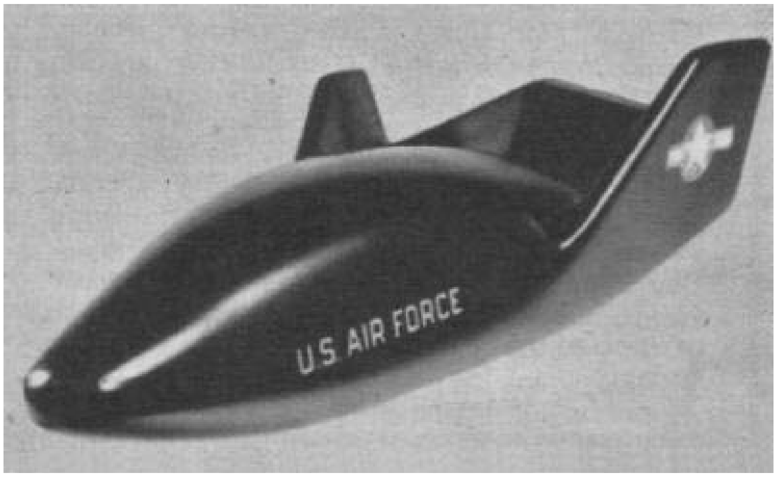
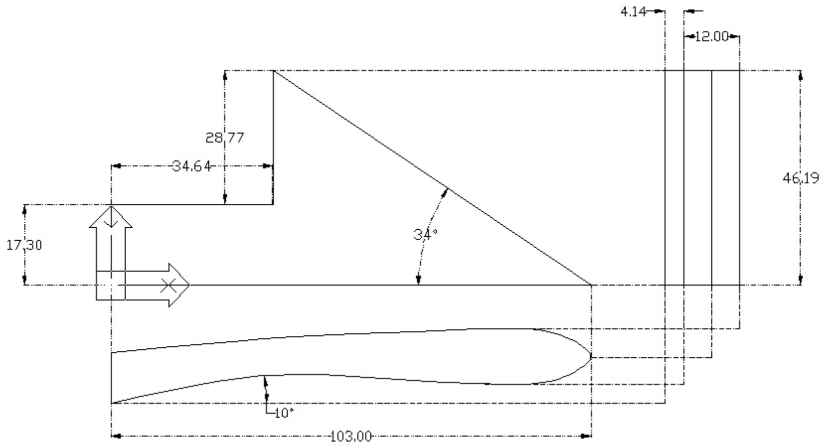


Figure 3-1 Example of Generic LEV Shape

Trajectory shaping and nominal dispersions were formulated after reviewing several documents on these subjects developed for the Space Shuttle and X-38 programs and discussing their content with knowledgeable government officials. It was assumed, for simplicity, that vehicle flight termination occurred immediately after onset of a malfunction maneuver; this eliminated the need to model the malfunction trajectories. Moreover, it was assumed that no significant incremental velocities were imparted to debris by the action of the flight termination system.

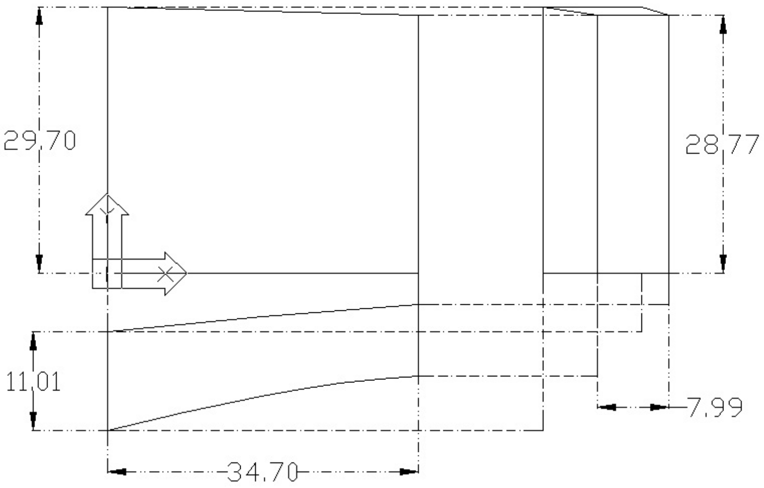
3.1 VEHICLE BREAKUP

Two credible breakup lists were postulated resulting either from aerodynamic load or a flight termination action. In the first case, the LEV remains intact until it impacts the earth. In the second case, the LEV breaks into seven components, as illustrated in Figures 3-2 through 3-4. These components are two vertical fins, two rudders, two body flaps, and the core LEV body.


4.14
12.00
28.77
34.64
17.30
34°
46.19
10°
103.00

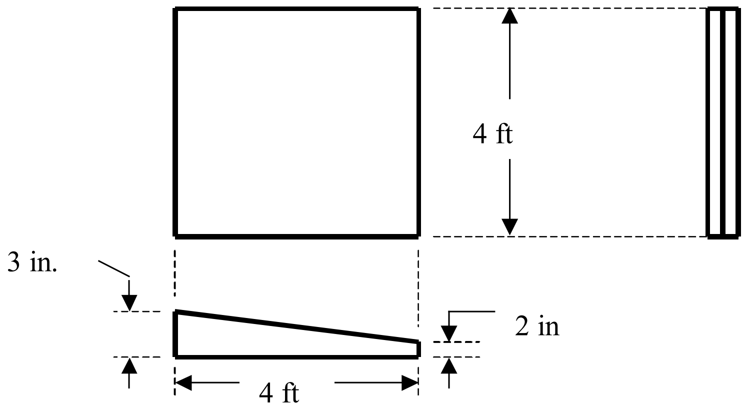
Note: Units in inches.

Figure 3-2 Generic LEV Vertical Fin (Right)


29.70
28.77
11.01
7.99
34.70

Note: Units in inches.

Figure 3-3 Generic LEV Rudder



Not to scale, approximate dimensions

Figure 3-4 Generic LEV Body Flap

For both breakup lists, all of the fragments were assumed to be inert, that is not capable of sustaining an explosion on impact.

Characterizing the fragment impact dispersions required modeling the fragment aerodynamic characteristics and their uncertainty and characterizing the atmospheric profile through which the debris would fall and the associated wind uncertainty. Each fragment was characterized by a ballistic coefficient, $\beta = \frac{W}{C_D A_{ref}}$, (the ratio of the fragment weight to the product of the drag coefficient and the aerodynamic reference area), uncertainty of the ballistic coefficient, σ_β, and uncertainty in the ratio of the fragment lift-to-drag ratio, $\sigma_{L/D}$. Debris characteristics were calculated based on the following assumptions:

The vertical fins, rudders, and body flaps were modeled as tumbling plates during their free fall. The intact vehicle and the main body of the LEV were modeled as tumbling cylinders. The drag coefficients are 0.87 and 0.58 for a tumbling plate and tumbling cylinder, respectively (Hoerner 1965). Ballistic coefficients were modeled as having a 10 percent coefficient of variation. The coefficient of variation was chosen to reflect both the anticipated uncertainty during entry as well as the generic nature of the analysis. The reference area (A_{ref}) for tumbling bodies is given by the following formula in terms of the fragment dimensions (L_1, L_2, L_3) by:

$$A_{ref} = \frac{4}{\pi^2}\left(L_1 L_2 + L_1 L_3 + \frac{\pi}{2} L_2 L_3 \right)$$

where $L_1 \geq L_2 \geq L_3$

Fragment characteristics are listed in Table 3-1.

Table 3-1
LEV Fragment Characteristics

Name	Weight (lbs)	Reference area (sq. ft)	Drag coefficient (C_D) (avg. tumble)	Ballistic coefficient (β) (psf)
Vertical Fin	314	11.1	0.87	28.3
Rudder	64.5	14.9	0.87	15.1
Flap	126.5	6.9	0.87	20.9
Main body	23,990	408.8	0.59	100
Whole vehicle	25,000	431.0	0.65	90

3.2 PROBABILITY OF FAILURE

Developing estimates of the probability of catastrophic failure for a generic LEV pose several challenges not present when developing the catastrophic failure probability for a specific launch vehicle. Failure probabilities for a class of vehicles must span the range in credible design concepts anticipated for that class. Moreover, they should reflect the conditions under which the LEV operates in contrast to the loads experienced by a launch vehicle.

Three rules were established early in the analysis:

1. The risk analysis was for a generic LEV; consequently, no event tree or failure mode and effect analyses were provided as a basis for estimating failure probabilities.

2. Constant failure rates were assumed to apply throughout the descent phase of flight. Two classes of failures are of concern: random failures and failures initiated by vehicle loads or actuating hardware, such as initiating a maneuver. The constant failure rate assumption is consistent with the random failures. However, the assumption may be challenged for the other classes of failures. For a *particular* LEV flying a *designated* trajectory, higher failure rates would be associated with the high load, maneuver initiation portions of flight.

   By contrast, for a *generic* vehicle flying a *class* of trajectories, these higher failure rate epochs were not regarded as predictable. Consequently, the simplifying assumption of constant failure rates was employed. In addition, recognizing these uncertainties, results were parameterized by failure rates.

3. One-half order of magnitude is sufficiently accurate to estimate the probability of failure for a generic LEV. This means for example, that candidate failure probabilities could include $10^{-3} = 1 \times 10^{-3}$, $10^{-2.5} = 3 \times 10^{-3}$, $10^{-2} = 1 \times 10^{-2}$, and $10^{-1.5} = 3 \times 10^{-2}$, etc. Using intermediate values will be regarded as implying greater accuracy than these calculations justify.

Two approaches were used to develop estimates of catastrophic LEV failures:

- Surrogate modeling; and

- Statistical data analysis.

The second approach derives from flight experience of the Space Shuttle and the X-15. This approach is a simple statistical analysis permitting the establishment of an upper limit on the probability as well as a point estimate.

3.2.1 Surrogate Model Analysis

In 1995, Science Applications International Corporation (SAIC) reported the results of surrogate model analysis of the reliability of the Space Shuttle performed for National Aeronautics and Space Administration (NASA) (Fragola and Gaspare 1995) that estimated the probability of a catastrophic failure of the Space Shuttle as 7.6×10^{-3}. Moreover, SAIC allocated this failure probability by flight phase as follows:

- 60 percent of the catastrophic (loss of vehicle) failure probability was attributed to the ascent phase;
- 35 percent of the catastrophic (loss of vehicle) failure probability applied to the descent phase; and
- 5 percent applied to the landing phase alone.

Using SAIC's total mission failure probability and the allocation to the descent phase results in an estimate of 2.7×10^{-3} (1/370).

3.2.2 Statistical Analysis

Both NASA and the U.S. Air Force have sponsored a variety of lifting body programs since the mid-1960s. These lifting bodies have ranged in complexity and sophistication from the M2-F1 glider, a rather simple wooden craft that made several hundred low-altitude, low-speed flights in the 1963–1964 time frame to the sophisticated Shuttle Orbiter, which has experienced the loads of the launch environment and the entry environment without a single failure. The statistical analysis that follows is based exclusively on the Shuttle Orbiter descents and the X-15 descents. While some of the other program experience may be argued to be applicable it has been excluded because of the differences in design concepts and loads to which those vehicles were subjected or because their small sample size would violate the rule of implying more accuracy than is justifiable. None of the potentially relevant programs experienced any relevant failures during the descent phase. Thus, omitting these data from the analysis is conservative in the sense of tending toward overstating the risk to life and property.

There have been 104 Shuttle descents without catastrophic failure (this excludes the Challenger mission that failed during ascent) and 199 X-15 descents with one catastrophic failure (Mission 191 on November 15, 1967). The X-15 catastrophic failure began with a slow change in heading as the X-15 approached its peak altitude. The automatic reaction control system operated intermittently to correct the heading, possibly confusing the pilot. The pilot apparently misinterpreted instrumentation read-outs and initiated manual reaction control resulting in loss of control until the aircraft broke up in its dive before hitting the ground (Godwin 1971).

This X-15 failure has been treated as relevant to an LEV in descent since it caused a potential debris hazard to the ground. Thus, the surrogate data to be considered in a statistical analysis are one failure in a total of 303 descents.

The point (mean) failure probability estimate is $1/303 = 3.31 \times 10^{-3}$

The percent upper confidence bounds for failure may be derived from the standard statistical chi-squared (χ^2) formulation:

$$P \text{ \% upper confidence bound} = \chi_P^2\left(2r+2\right)/\left(2N\right)$$

where P = percent
r = number of failures
N = number of flights

90% upper confidence bound = $\chi_{90}^2(4)/606 = 7.78/606 = 1.3 \times 10^{-2} = 1/78$

95% upper confidence bound = $\chi_{95}^2(4)/606 = 9.49/606 = 1.6 \times 10^{-2} = 1/64$

Were the X-15 failure to be regarded as not relevant to the LEV program, the mean failure probability estimate would be zero. The upper confidence bounds would be

90% upper confidence bound = $\chi_{90}^2(2)/606 = 4.61/606 = 7.6 \times 10^{-3} = 1/131$

95% upper confidence bound = $\chi_{95}^2(2)/606 = 5.99/606 = 9.9 \times 10^{-3} = 1/101$

An estimate of the median as an alternative point estimate in the cases of zero failures is derived as the arithmetic average of the χ^2 - based upper and lower bounds on the 50th percentile:

50% upper confidence bound = $\chi_{50}^2(2)/606 = 1.59/606 = 2.3 \times 10^{-3}$

50% lower confidence bound = 0.0

Median estimate = 1.2×10^{-3}

As a reference point, it is noted that since 1980, there have been 2,106 Expendable Launch Vehicles (ELVs) launched internationally (some incorporated solid rocket strap-ons). These ELVs have experienced 45 catastrophic failures[1]. Fourteen of these failures resulted from attitude control malfunctions, guidance and navigation failures, or structural failures. The remainder involved systems not applicable to LEVs.

The point (mean) failure probability estimate for these ELV failures is $14/2106 = 6.6 \times 10^{-3}$. The upper confidence bound would be

90% upper confidence bound = $\chi_{90}^2(30)/4212 = 40.26/4212 = 9.6 \times 10^{-3} = 1/104$

95% upper confidence bound = $\chi_{95}^2(30)/4212 = 43.77/4212 = 1.04 \times 10^{-2} = 1/96$

These ELV-based numbers qualitatively confirm the plausibility of the LEV based estimates.

---

[1] Catastrophic failures are defined as those failures that could lead to risk to the public. Failures such as improper orbit or failure to separate the payload are not considered catastrophic.

3.2.3 Recommended Failure Probabilities

The range of LEV based point estimates[2] that have been derived is 1.2×10^{-3} to 3.3×10^{-3}, with a central value of 2.25×10^{-3} (1/ 440). The range of the upper limits is 1.3×10^{-2} to 1.6×10^{-2}, with a central value of 1.5×10^{-2} (1/ 67). Therefore, to one-half order of magnitude, the estimated failure probability is 3×10^{-3} (3 in 1,000).

Note, however, that the designs of the Shuttle systems are largely 30 years old. The X-15 flew for some 10 years starting 40 years ago. Thus, it is plausible that the surrogate information-based estimates that have been derived here may not account for the potentially greater design reliability of an LEV's new systems. On the other hand, the Shuttle and the X-15 had human pilots to back up their physical systems and so an LEV could have lower operational reliability (although in the case of the X-15 accident, the pilot apparently contributed to the loss of control).

Nevertheless, it is reasonable to expect that a modern LEV design consistent with failure probabilities in the range of 3×10^{-3} to 3×10^{-2} (3 in 1,000 to 3 in 100) should be easily achievable. Given the nominal descent period of 2,000 seconds, this corresponds to a failure rate range of 1.5×10^{-6} to 1.5×10^{-5} failures per second.

3.3 TRAJECTORY MODELING

The trajectory of a generic LEV is expected to be similar to the trajectory used by the X-38 with the final approach and landing via a HAC similar to the Space Shuttle, landing from the northeast on runway 22 at Edwards AFB. A HAC is the final portion of the descent (approximately the last 30,000 feet) which is a transition from the entry trajectory direction to the runway direction. This maneuver spans an arc between 180 and 360 degrees with an approximate radius of 7 nautical miles.

To maintain the generic nature of this analysis, the energy management maneuvers were removed from the X-38 trajectory to produce straight (great circle) reference trajectories. Trajectory profiles are shown in Figures 3-5 and 3-6.

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[2] Including the median point estimate that arises if the X-15 failure is ignored.

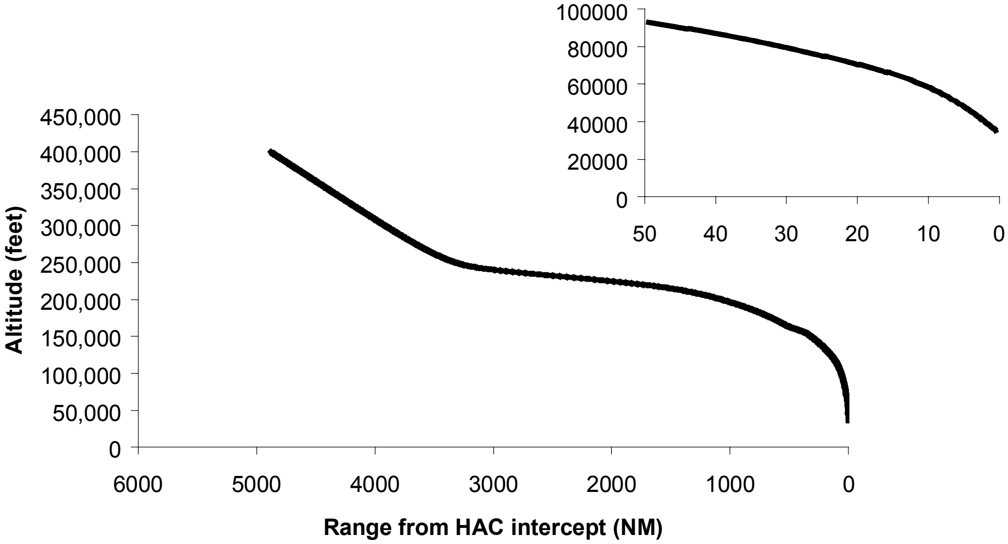

Figure 3-5 Altitude Profile of Generic Trajectory

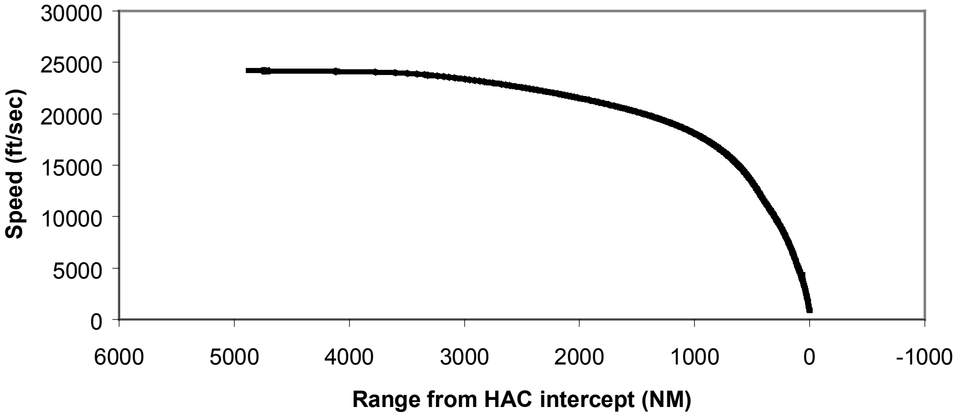

Figure 3-6 Speed Profile of Generic Trajectory

In order to determine the range of descent azimuths for which risk levels are acceptable, it was necessary to assess risks for many different trajectories. Therefore, trajectories were calculated at one degree azimuth increments for azimuths ranging from 215 degrees (over the edge of the Los Angeles metropolitan area) to 020 degrees.

These trajectories were matched to the HAC using the following procedure:

1. Calculate the HAC backward from the end of the runway to the HAC intercept point, using several reference points read from figures describing Space Shuttle landings (Office of Advanced Manned Vehicles [OAMV] 1985). This calculation was performed in the crossrange / downrange / above ground level (AGL) coordinates.

2. Convert the HAC to latitude / longitude / mean sea level (MSL) coordinates for both a left-hand HAC and a right-hand HAC, using the runway coordinates. These HAC intercept points are r_{LH} and r_{RH}.
3. Determine the point in the reference trajectory with altitude closest to HAC intercept altitude (MSL). Call this reference point r_1.
4. For each point in the reference trajectory at higher altitude r_1, calculate the distance from r_1. These distances are $\mathbf{d}_{\text{Ref}}$.
5. A new trajectory is created by determining the point at each azimuth for which a trajectory is desired the distances $\mathbf{d}_{\text{Ref}}$ from r_{LH} or r_{RH}. The left hand HAC is used if the azimuth is greater than the runway azimuth, i.e., the vehicle will always go at least 180 degrees around the HAC.

Figure 3-7 shows a section of four example trajectories in the vicinity of Edwards AFB (Edwards AFB is the large blue area). Two of the trajectories (shown in yellow [trajectory 2] and purple [trajectory 4]) are on either side of the cross-over point between the left-hand and right-hand HAC.

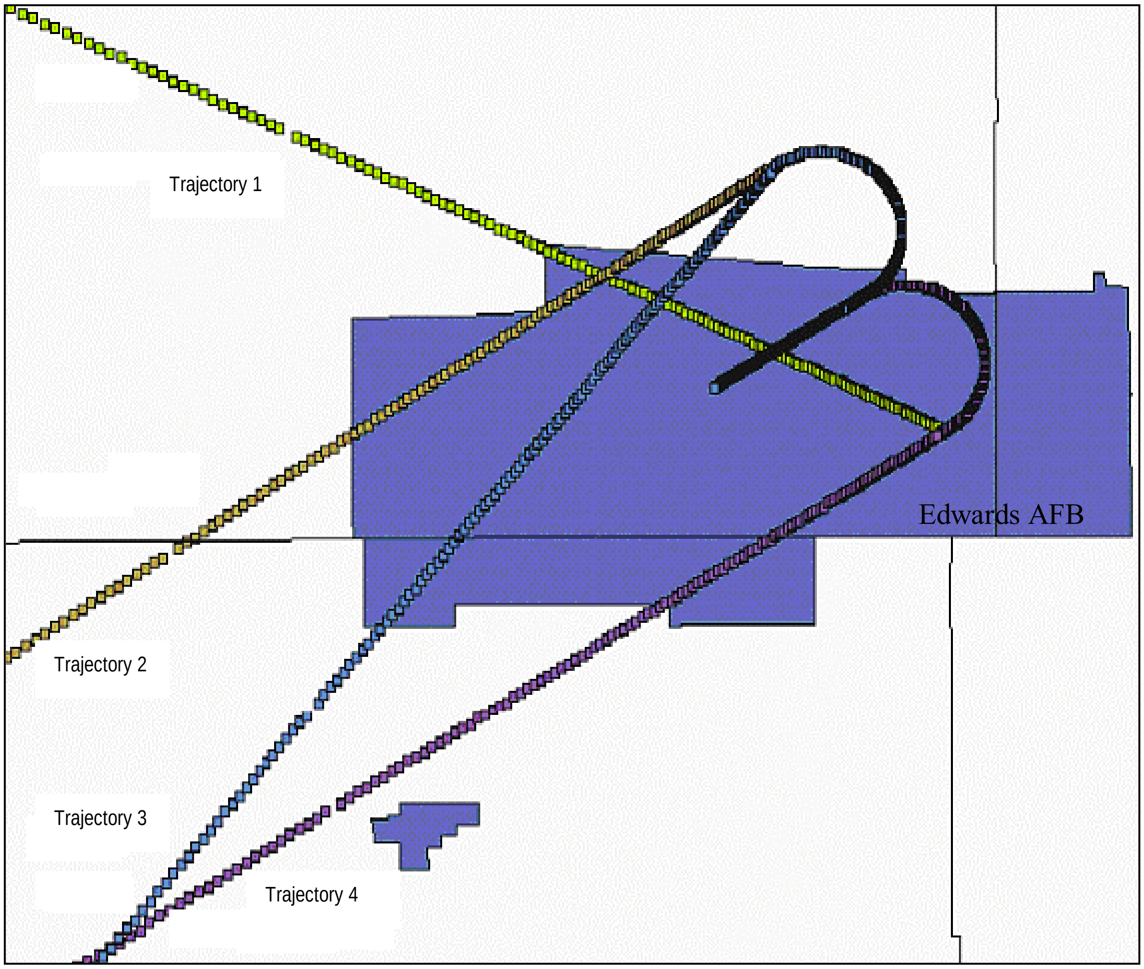

Figure 3-7 Generic LEV Trajectories near Edwards AFB

Figure 3-8 shows the same trajectories on a larger scale, with the black lines indicating California county boundaries. The two trajectories on either side of the switch in HACs cross a large distance away from the landing site. Interestingly, of these two, the trajectory with the more northerly azimuth is further south for most of the flight. The effects of this are discussed in the section on risk analysis.

A weakness of this method is that the transition from the trajectory to the HAC is not smooth (especially when the trajectory azimuth is significantly different from the runway azimuth). Although the position of the vehicle never jumps, the velocities are not continuous—there is a sharp turn when the vehicle enters the HAC (an infinite acceleration). A possibly better approach for determining the trajectory/HAC transition would be to calculate it in such a way that the velocities are also continuous. However, the variations in the trajectories of specific vehicles, such as a different radius HAC, may produce effects of similar magnitudes.

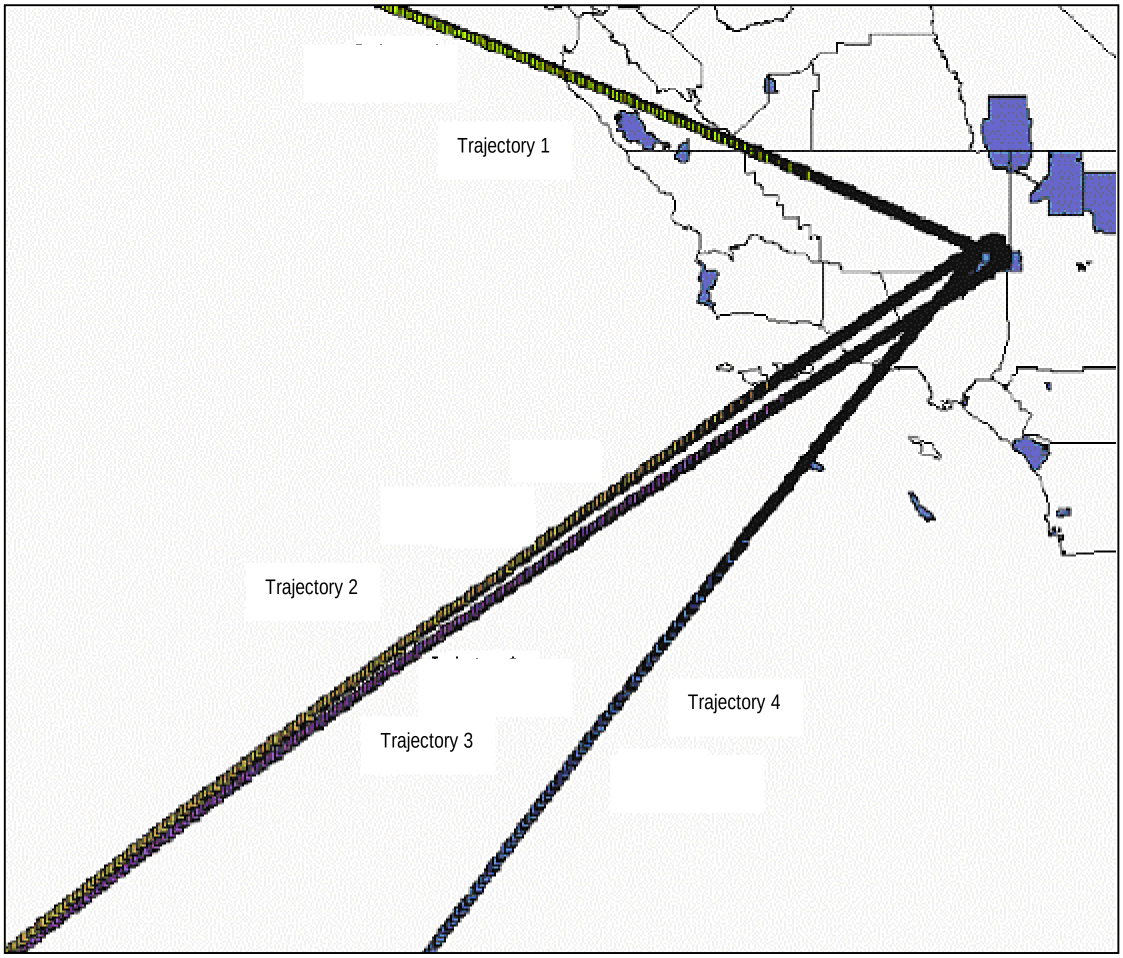
Trajectory 1
Trajectory 2
Trajectory 3
Trajectory 4

Figure 3-8 Generic LEV Trajectories to Edwards AFB

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4.0 RISK TO GROUND-LEVEL ASSETS

The risk to the ground population was determined from a calculation of the casualty expectation and impact probability using Common Real Time Footprint (CRTF), a code originally developed to support real-time evaluation of the instantaneous debris footprint for a launch vehicle and later generalized to perform more general debris risk analyses. The risk evaluation employed a model of the location and sheltering levels for people at risk described later in this section. A model of sheltering was developed for the western United States and western Canada based on census data. Sensitivity of the computed risks to several important input parameters was also evaluated. Risks in the form of casualty expectation were computed for a range of approach azimuths for various failure probabilities, and these risk levels were evaluated against flight safety standards.

4.1 METHOD OF RISK CALCULATION: CRTF

The CRTF was designed to compute the dispersions that define an instantaneous scenario of a vehicle breakup and dispersion of debris. It can be used as a subroutine in a risk analysis program that generates a large number of state vectors describing all of the potential accident/failure conditions along with their corresponding probabilities. The risk calculation methodology uses a series of bivariate normal distributions, each representing the impact distribution for a different debris category. These distributions provide the basis of the probabilistic model. Most of the dispersion models in CRTF originated in the launch risk analysis (LARA) program (Baeker *et al.* 1977).

The two most dominant effects on footprint length and shape are the ballistic coefficient of the debris and the wind. The debris with very low ballistic coefficients decelerates very quickly and, if the wind is light, falls to the ground close to the sub-missile point at the time of breakup. If the wind is strong, the debris will move with the wind and land in the direction of the wind relative to the breakup point. Debris with very high ballistic coefficients shows little effect of the wind and will land in the direction of the vacuum impact point. Figure 4-1 illustrates the effects of ballistic coefficient and wind on the “centerline” of debris footprint.

The dispersion relative to the debris centerline is the result of uncertainties from a number of sources. These are illustrated in Figure 4-2. The “disks” around the impact points in Figure 4-2 represent the impact uncertainty of debris due to the uncertainty sources. Four pieces of debris are shown, but actually there can be thousands. To simplify the modeling process, debris pieces are grouped into classes. There may be 50 or more classes, each containing debris pieces that have similar ballistic coefficients, explosive characteristics or velocity perturbation characteristics. CRTF simulates the behavior and impact dispersions of each of these groups and then, in the final step, adjusts the statistical results to account for the number of fragments in the group.

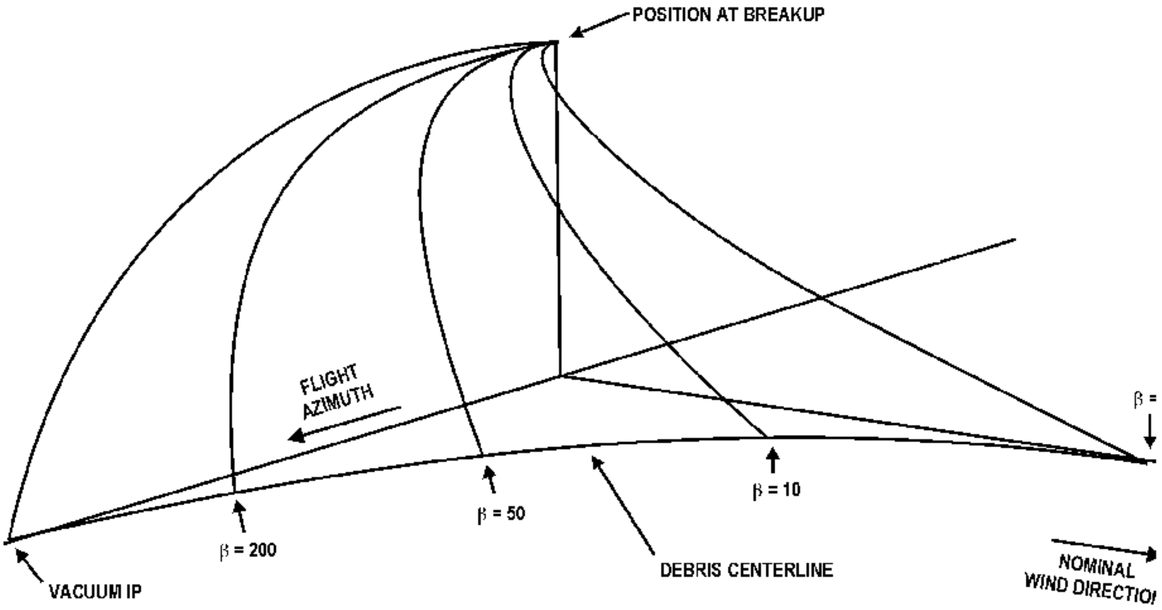

POSITION AT BREAKUP
FLIGHT AZIMUTH
β =
β = 10
β = 50
β = 200
VACUUM IP
DEBRIS CENTERLINE
NOMINAL WIND DIRECTIO

Figure 4-1 Influence of Ballistic Coefficient, β, and Wind on Debris Impact Points

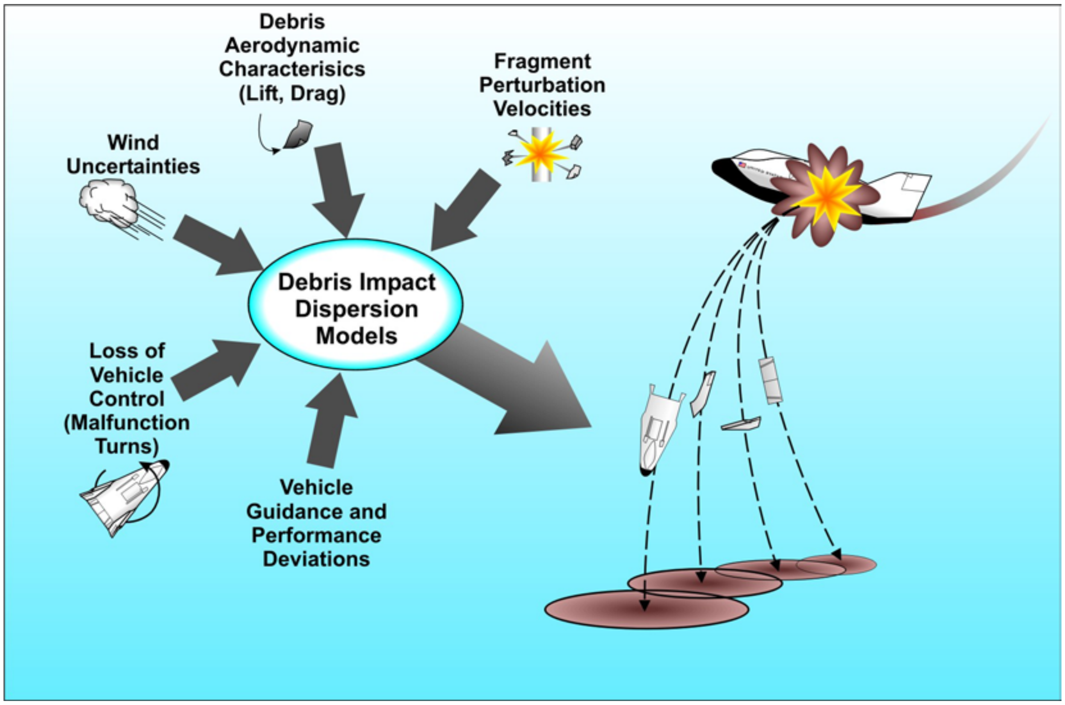

Debris Aerodynamic Characterisics (Lift, Drag)
Fragment Perturbation Velocities
Wind Uncertainties
Debris Impact Dispersion Models
Loss of Vehicle Control (Malfunction Turns)
Vehicle Guidance and Performance Deviations

Figure 4-2 Contributions to Debris Dispersion Models

The speed of the CRTF code is a result of the original requirement to operate in real-time with an update rate of 10 times per second. Another specification of the program was that it must predict debris dispersions based on input state vectors. The impact predictor within CRTF does not use a typical Runge Kutta algorithm, but uses a faster three and one-half order Taylor series concept (non-corrective) that, after adjustment, proved to be quite accurate. The code has been cross validated against the LARA code and against a Sandia risk analysis code designed to perform debris risk analyses on a supercomputer.

The CRTF contains a set of models that estimate the range of free-fall and impact locations of the fragments that result from vehicle breakup. The initiating event is assumed to be the activation of the on-board flight termination system, leading to an effective vehicle thrust termination and breakup into a fixed set of fragments. The program accommodates other breakup conditions (e.g., aerodynamic) as well. The CRTF models quantify the uncertainties that exist in the vehicle location at the moment of breakup, in the characteristics of the generated fragment debris, and in the external conditions during fragment free-fall. There are six uncertainty models in CRTF, four of which employ a Monte Carlo technique. The Monte Carlo routines are used to handle some of the uncertainties and develop impact distributions that contribute to the total uncertainty. The other impact uncertainties are developed using linear equations and covariance propagation, thus the program is a hybrid, taking advantages of the best of both statistical modeling methods.

The four models applicable to the LEV entry risk analysis are described in the following paragraphs.

(1) A vehicle state vector is passed to CRTF, corresponding to mean conditions at breakup. The uncertainty in this state vector is represented by a covariance matrix containing both position and velocity uncertainty along each of three orthogonal axes. The model in CRTF assumes a normal distribution in each direction, and generates Monte Carlo samples for each of the six degrees of freedom.

$$\sum(x,y,z,\dot{x},\dot{y},\dot{z}) = \begin{bmatrix} \sigma_x^2 & \rho_{xy}\sigma_x\sigma_y & \rho_{xz}\sigma_x\sigma_z & \rho_{x\dot{x}}\sigma_x\sigma_{\dot{x}} & \rho_{x\dot{y}}\sigma_x\sigma_{\dot{y}} & \rho_{x\dot{z}}\sigma_x\sigma_{\dot{z}} \\ \rho_{yx}\sigma_y\sigma_x & \sigma_y^2 & \rho_{yz}\sigma_y\sigma_z & \rho_{y\dot{x}}\sigma_y\sigma_{\dot{x}} & \rho_{y\dot{y}}\sigma_y\sigma_{\dot{y}} & \rho_{y\dot{z}}\sigma_y\sigma_{\dot{z}} \\ \rho_{zx}\sigma_z\sigma_x & \rho_{zy}\sigma_z\sigma_y & \sigma_z^2 & \rho_{z\dot{x}}\sigma_z\sigma_{\dot{x}} & \rho_{z\dot{y}}\sigma_z\sigma_{\dot{y}} & \rho_{z\dot{z}}\sigma_z\sigma_{\dot{z}} \\ \rho_{\dot{x}x}\sigma_{\dot{x}}\sigma_x & \rho_{\dot{x}y}\sigma_{\dot{x}}\sigma_y & \rho_{\dot{x}z}\sigma_{\dot{x}}\sigma_z & \sigma_{\dot{x}}^2 & \rho_{\dot{x}\dot{y}}\sigma_{\dot{x}}\sigma_{\dot{y}} & \rho_{\dot{x}\dot{z}}\sigma_{\dot{x}}\sigma_{\dot{z}} \\ \rho_{\dot{y}x}\sigma_{\dot{y}}\sigma_x & \rho_{\dot{y}y}\sigma_{\dot{y}}\sigma_y & \rho_{\dot{y}z}\sigma_{\dot{y}}\sigma_z & \rho_{\dot{y}\dot{x}}\sigma_{\dot{y}}\sigma_{\dot{x}} & \sigma_{\dot{y}}^2 & \rho_{\dot{y}\dot{z}}\sigma_{\dot{y}}\sigma_{\dot{z}} \\ \rho_{\dot{z}x}\sigma_{\dot{z}}\sigma_x & \rho_{\dot{z}y}\sigma_{\dot{z}}\sigma_y & \rho_{\dot{z}z}\sigma_{\dot{z}}\sigma_z & \rho_{\dot{z}\dot{x}}\sigma_{\dot{z}}\sigma_{\dot{x}} & \rho_{\dot{z}\dot{y}}\sigma_{\dot{z}}\sigma_{\dot{y}} & \sigma_{\dot{z}}^2 \end{bmatrix}$$

where: σ_x is the standard deviation of x,
σ_y is the standard deviation of y, etc.
ρ_{xy} is the correlation coefficient of between the two variables, x and y. The x, y, z coordinate system is Cartesian in whatever frame used by the real-time system.

(2) The size and shape of each fragment determines the drag effect during free-fall. The parameter that quantifies this atmospheric influence is the ballistic coefficient of the fragment. Due to the uncertain nature of the breakup of the vehicle, each fragment can only be assigned a range of ballistic coefficients. The values in this span are taken to obey a split normal distribution (the standard deviation for values greater than the mean may be different from the standard deviation for values below the mean), where the two extremes and nominal value are specified by input to CRTF. The ballistic coefficient uncertainty model in CRTF generates Monte Carlo samples for each fragment category just prior to initiating the free-fall propagator.

(3) During free-fall, the fragments experience a lift effect where the piece is subjected to a force perpendicular to its direction of motion. The lift force is largest for flat plates (as an aircraft wing), and at lower altitudes where the air density is greatest. The magnitude of the lift force

fluctuates as the fragment tumbles since the surface along the direction of motion changes. The lift model in CRTF computes two impact points, starting from the initial state position. One location is for a fragment that sees no lift, and the second for a fragment that is given a constant lift. The lift is computed using a lift-to-drag coefficient that relates the relative effect compared to drag, and which is specified in the CRTF input for each fragment category.

(4) An external source of uncertainty applied to each fragment during free-fall is the strength of the wind. The centerline is based on the best estimate of the wind profile. For the LEV risk analysis, mean monthly wind profiles were employed. The input to this calculation used wind variability data acquired over a period of years, which quantifies how much the wind speed and direction may vary over each monthly period at a given altitude. A wind covariance matrix is shown below. The wind dispersion effect is determined by computing the time a fragment traveling at terminal velocity passes through an altitude band and, assuming that the fragment is embedded in the wind, the fragment while falling through the band moves laterally at the velocity of the wind. This assumption is quite accurate for low ballistic coefficient debris (β=1 to 10 psf) and less so as β increases. Fortunately, the effect of ballistic coefficient on drift decreases as 1/√β. The wind covariance matrix and the matrix product to obtain impact dispersions due to wind are given below.

$$\left[\sum\nolimits_{\text{Wind}}^{\text{EN}}\right]_h = \begin{bmatrix} \sigma_E^2 & \sigma_{EN} \\ \sigma_{EN} & \sigma_N^2 \end{bmatrix} = \left[\begin{array}{c|c} \Delta t & 0 \\ \hline 0 & \Delta t \end{array}\right]_h \left[\sum\nolimits_{\text{Wind}}\right]_h \left[\begin{array}{c|c} \Delta t & 0 \\ \hline 0 & \Delta t \end{array}\right]_h^T$$

$$\sum\nolimits_{\text{Wind}} = \left[\begin{array}{cccc|cccc} \sigma_{E_1}^2 & \sigma_{E_1E_2} & \cdots & \sigma_{E_1E_n} & \sigma_{E_1N_1} & \sigma_{E_1N_2} & \cdots & \sigma_{E_1N_n} \\ \sigma_{E_2E_1} & \sigma_{E_2}^2 & \cdots & \sigma_{E_2E_n} & \sigma_{E_2N_1} & \sigma_{E_2N_2} & \cdots & \sigma_{E_2N_n} \\ \vdots & \vdots & \ddots & \vdots & \vdots & \vdots & \ddots & \vdots \\ \sigma_{E_nE_1} & \sigma_{E_nE_2} & \cdots & \sigma_{E_n}^2 & \sigma_{E_nN_1} & \sigma_{E_nN_2} & \cdots & \sigma_{E_NN_n} \\ \hline \sigma_{N_1E_1} & \sigma_{N_1E_2} & \cdots & \sigma_{N_1E_n} & \sigma_N^2 & \sigma_{N_1N_2} & \cdots & \sigma_{N_1N_n} \\ \sigma_{N_2E_1} & \sigma_{N_2E_2} & \cdots & \sigma_{N_2E_n} & \sigma_{N_2N_1} & \sigma_{N_2}^2 & \cdots & \sigma_{N_2N_n} \\ \vdots & \vdots & \ddots & \vdots & \vdots & \vdots & \ddots & \vdots \\ \sigma_{N_nE_1} & \sigma_{N_nE_2} & \cdots & \sigma_{N_nE_n} & \sigma_{N_nN_1} & \sigma_{N_nN_2} & \cdots & \sigma_{N_n}^2 \end{array}\right]$$

Note, $\sigma_{E_iE_j} \equiv \rho_{E_iE_j}\sigma_{E_i}\sigma_{E_j}$, etc.

For each active fragment group, the above four sources of uncertainty were combined by building three impact covariance matrices as follows. A set of N Monte Carlo simulations are set up to represent selections of random conditions. For each simulation, CRTF sample the ballistic coefficient of the fragment group. The fragment is then propagated to the ground, leading to N impact points from which the first impact covariance matrix is computed. For lift, the second impact covariance is defined by treating the separation of the two impact points (lift and no-lift) as standard deviations. The third impact covariance matrix, due to wind, is constructed by a more technical procedure that is omitted here. The total impact covariance is the sum of the three matrices. The procedure is shown in the flow diagram in Figure 4-3.

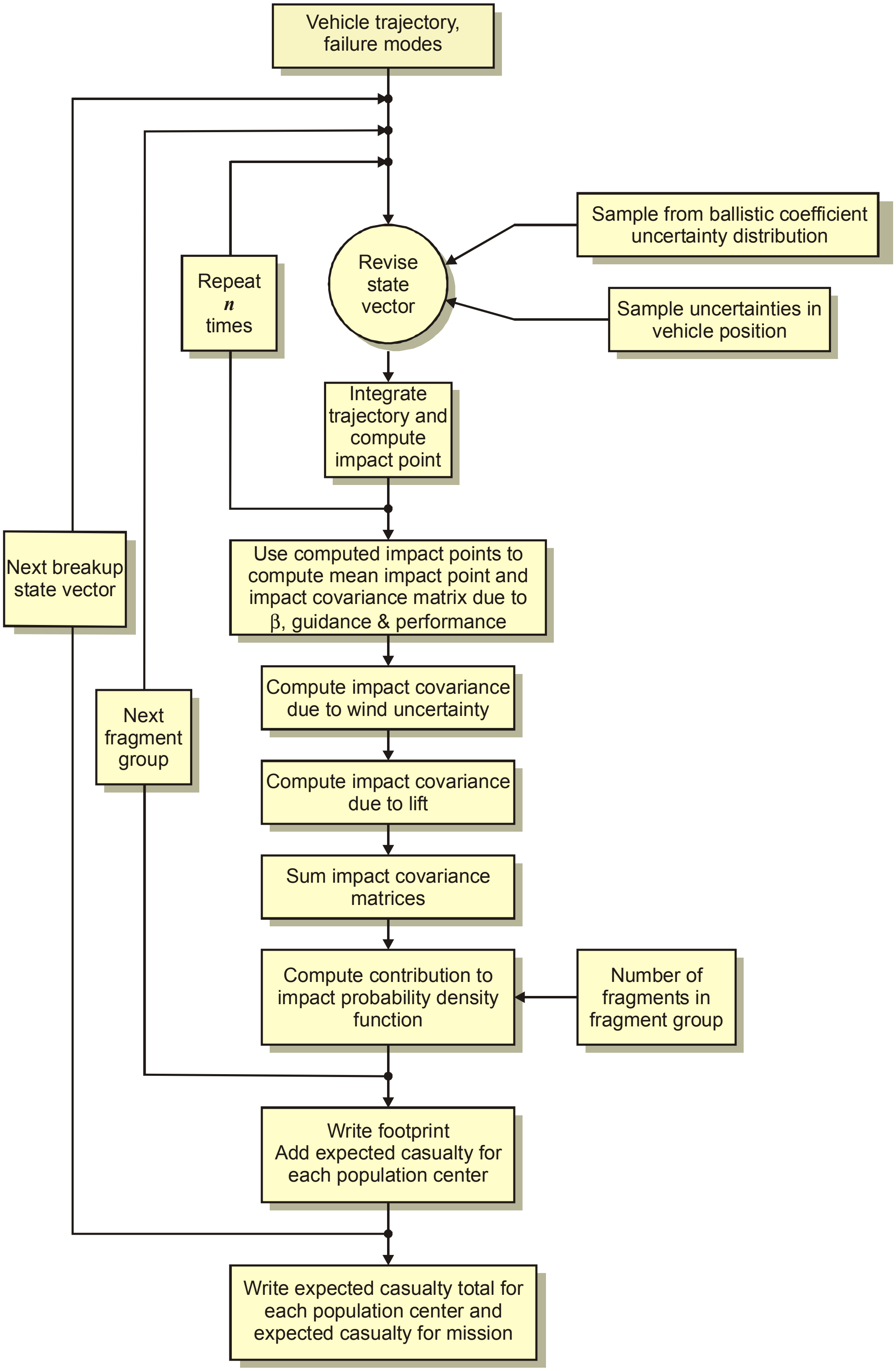

Vehicle trajectory, failure modes
Sample from ballistic coefficient uncertainty distribution
Repeat *n* times
Revise state vector
Sample uncertainties in vehicle position
Integrate trajectory and compute impact point
Next breakup state vector
Use computed impact points to compute mean impact point and impact covariance matrix due to β, guidance & performance
Compute impact covariance due to wind uncertainty
Next fragment group
Compute impact covariance due to lift
Sum impact covariance matrices
Compute contribution to impact probability density function
Number of fragments in fragment group
Write footprint Add expected casualty for each population center
Write expected casualty total for each population center and expected casualty for mission

Figure 4-3 Computational Procedure used by CRTF

At the end of the dispersion analysis, each debris group has a mean impact point and a covariance matrix defining the impact uncertainties. The covariance matrix (in East-North coordinates) contains the information for finding the size and orientation of the impact ellipse.

$$\Sigma_{EN} = \begin{bmatrix} \sigma_E^2 & \rho_{EN}\sigma_E\sigma_N \\ \rho_{EN}\sigma_E\sigma_N & \sigma_N^2 \end{bmatrix}$$

The eigenvalues and eigenvectors of Σ_{EN} provide the magnitudes of the major and minor axes and the orientation of the axes.

$$\Sigma_{EN}\begin{bmatrix} E \\ N \end{bmatrix} = \lambda^2\begin{bmatrix} E \\ N \end{bmatrix} \quad => \quad \left(\Sigma_{EN} - \lambda^2\mathbf{I}\right)\begin{bmatrix} E \\ N \end{bmatrix} = 0$$

$$\det\begin{bmatrix} \sigma_E{}^2 - \lambda^2 & \sigma_{EN} \\ \sigma_{EN} & \sigma_N{}^2 - \lambda^2 \end{bmatrix} = 0$$

The two values for λ^2, solved from the above determinant, are the equivalent values of the standard deviation along the two orthogonal axes rotated by the angle α as shown below. The angle α is determined by the ratios of E/N computed in the above matrix equation after the computed values of λ^2 have been substituted into the equation.

The ellipse showing the rotation and the relative lengths of the major and minor axes is shown in Figure 4-4. The two standard deviations ($\sigma_\eta^2 = \lambda_1^2$ and $\sigma_\varsigma^2 = \lambda_2^2$) define a bivariate normal distribution that is used to compute impact probabilities to population centers.

$$\tan\alpha = \frac{\sigma_N{}^2 - \sigma_E{}^2}{\rho_{EN}\ \sigma_E\sigma_N}$$

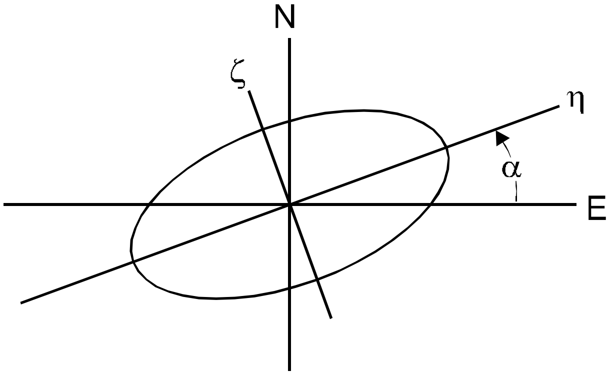


Figure 4-4 **Rotation to a Coordinate System with No Off-Diagonal Terms in the Covariance Matrix**

Casualty expectation for a population center in which all persons are provided the same level of sheltering may be expressed as the product of the number of people in the population center, the probability of impact on the population center, and the probability of a person becoming a casualty given that the debris impacts the population center. The probability a person will become a casualty given that debris impacts the population center is the ratio of the "casualty area" of the fragment to the area of the population center.

Casualty areas are computed separately for sheltered persons and unsheltered persons. When a fragment impacts an unsheltered region, its casualty area is augmented by additional area it sweeps out if it descends at some angle with respect to the vertical. In addition, the fragment may bounce, splatter, or roll after it initially strikes the ground. The casualty area model addresses these increases in the area placed at risk. Moreover, when a fragment impacts a person the chance of severe injury (casualty) depends on the fragment characteristics including its shape, mass, and impact velocity. In addition, the effect of an impact varies with the body part struck. The casualty area model combines all of these factors using appropriate probabilistic expressions to develop a casualty area for each impacting fragment for unprotected persons.

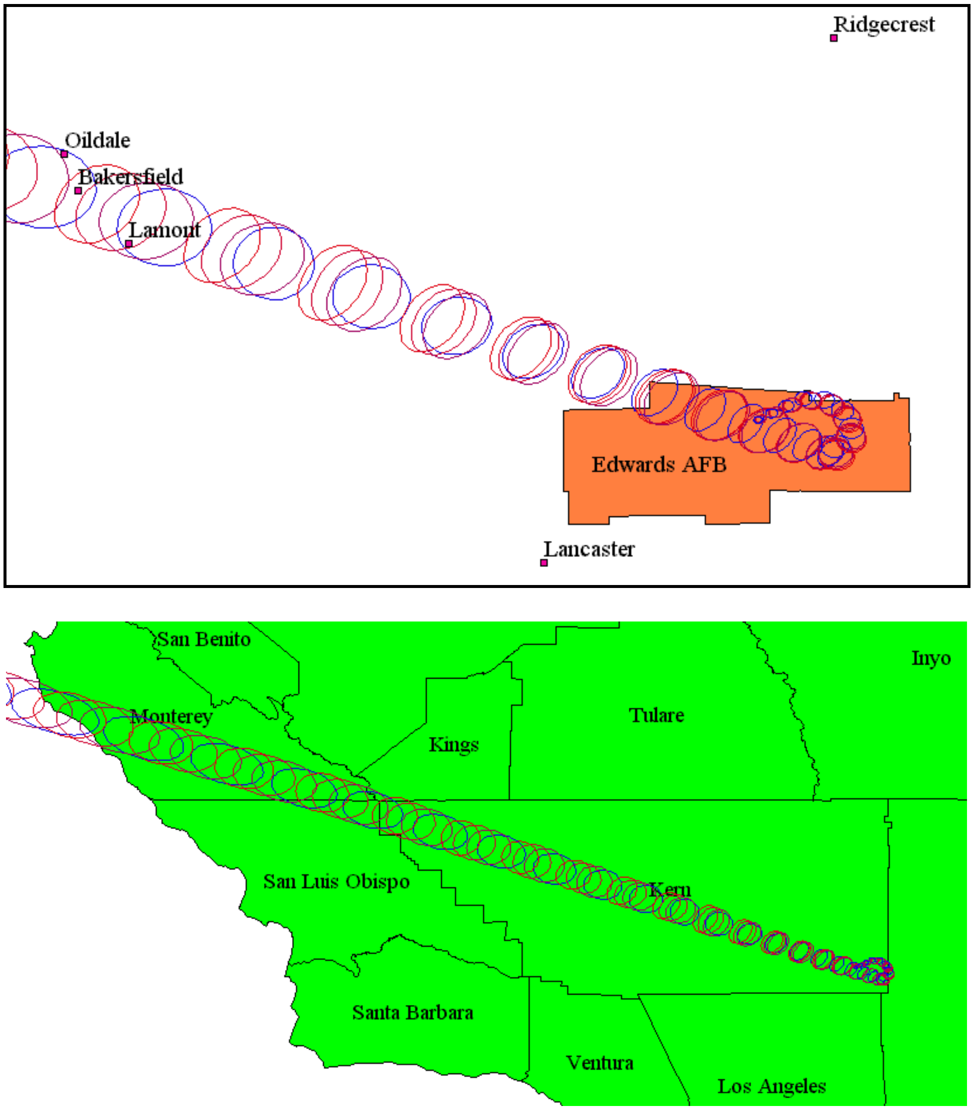
When a fragment strikes a structure, the program evaluates the probability of the fragment penetrating or collapsing the roof (segments). This algorithm addresses the variations in vulnerability of a roof as a function of impact location. (It is more difficult to cause a section to fail when the impact location is over a supporting beam than when it is between beams.) When the program predicts roof failure, it predicts the characteristics of the secondary debris resulting from the failure and the residual velocity of the original impacting fragment. The characteristics of this debris are used in conjunction with the human vulnerability models alluded to above to compute probabilistic casualty areas to persons housed on the floor immediately below roof level. For multistory buildings this process is repeated for each floor. Risks are accumulated over all sheltering levels, all fragment groups, all failure times, and all population centers to compute mission risk.

4.2 GROUND IMPACT PROBABILITIES

This section presents figures that may be used to predict risks to specific assets on the ground other than people. Assets such as environmentally sensitive habitats, cultural landmarks, and high-value property have not been specifically assessed in this report. However, the figures in this section may be used to estimate the probability of debris impacting a specific location. The risk to a particular asset may be inferred from this impact probability.

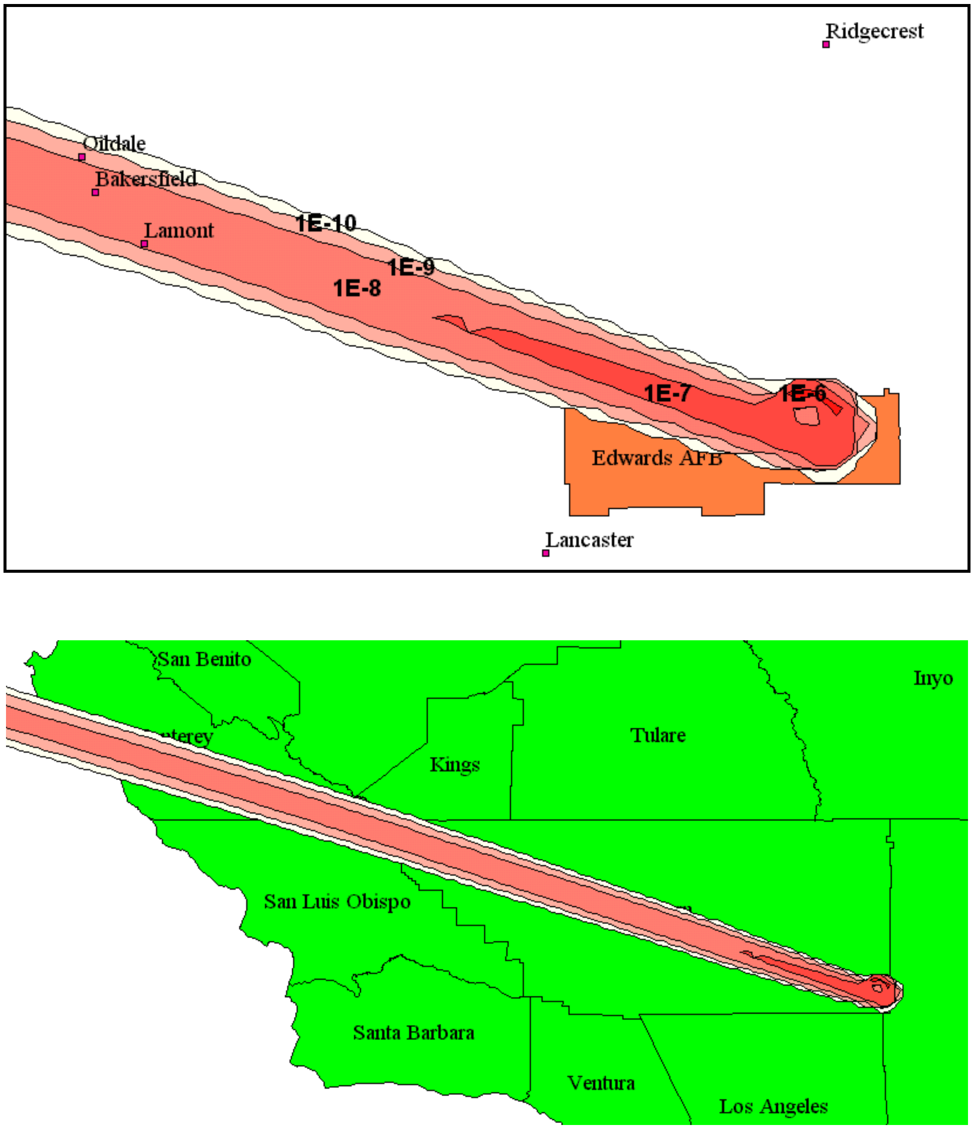
Figure 4-5 shows debris footprints for a sample trajectory from an azimuth of 293 degrees. It was calculated with a failure probability of 3×10^{-3} (3 per 1,000), with failures every 10 seconds along the trajectory. The vehicle was assumed to break into seven pieces. Ellipses indicate the one-sigma area of the probability density function for each fragment group at these failure times. The ellipses are roughly circular because the dominant factor is wind uncertainty, which in this case is close to isotropic. The blue ellipse is the LEV main body and has the largest ballistic coefficient, causing it to lead the other fragment groups. This occurs because lower ballistic coefficient fragments are more rapidly decelerated by atmospheric drag. The footprints become closer together and smaller as the vehicle approaches the landing point. They are closer together because the vehicle is slowing down, so in the 10-second time interval between failures (in this example) the vehicle travels a shorter distance. The ellipses are smaller because, as the vehicle approaches the landing point, the fragments fall a shorter distance between failure and the ground. This gives less time for the uncertainties in the winds to expand the region in which a fragment might fall.

Figure 4-6 shows a representative impact probability density contour plot at ground level for the same example trajectory (293 degrees, 3×10^{-3} failure probability, seven-piece breakup mode). The impact probability was calculated for a reference area of 1,000 square feet. The maximum P_I occurs at the end of the trajectory where the debris footprints are smaller (therefore higher probability per unit area) and are closer together (debris from consecutive breakup times have a larger area of overlap). Note, however, that the resolution of the grid is not sufficient to show the P_I accurately near the landing point.


Ridgecrest
Oildale
Bakersfield
Lamont
Edwards AFB
Lancaster
San Benito
Inyo
Monterey
Tulare
Kings
San Luis Obispo
Kern
Santa Barbara
Ventura
Los Angeles

Note: Blue indicates the large fragment; red indicates the smaller fragments (3 pairs).

Figure 4-5 Debris Footprints for Sample Trajectory


Ridgecrest
Oildale
Bakersfield
Lamont
1E-10
1E-9
1E-8
1E-7
1E-6
Edwards AFB
Lancaster
San Benito
Inyo
Monterey
Tulare
Kings
San Luis Obispo
Santa Barbara
Ventura
Los Angeles

Note: Each contour interval represents an order of magnitude. The reference area is 1,000 ft^2.

Figure 4-6 Impact Probability Density Contours for Sample Trajectory

4.3 DEVELOPMENT OF POPULATION DISTRIBUTION AND SHELTERING MODELS

For a large region, sheltering must be estimated from existing statistics of population and building types. Population statistics and sheltering data have been gathered for small regions (such as a military base) by specialized direct surveys, but it is impractical to initiate a survey for large regions. For these situations, the census results provide detailed population counts and other data that can be used as a basis to determine sheltering for risk analyses.

This section outlines a process which maps the data in the census to the number of people in “heavy,” “medium,” and “light” structures, and the number in the open. Sheltering results because people are inside, most commonly at home, at work, or at school. Therefore the problem can be broken down into determining the number of people in each of those activities and the sheltering associated with each activity. Since the census does not directly provide sheltering information, a mapping from the census data to the heavy, medium, light, and open sheltering categories must be used. The variables for sheltering are defined in Table 4-1.

Table 4-1
Variables for Modeling Sheltering

Variable name	Description
p	Population in a given population center
d	Percentage of people at home who are outside (1-d is the percentage of people at home who are inside)
s	Percentage of people in school
e	Percentage of people at work
o, a vector elements o_{ij}	Percentage of people who are at work who are in each occupation category
O, a matrix elements O_{ij}	Percentage of people in each occupation category who are assigned to each sheltering type
s, a vector elements s_{ij}	Percentage of students in school who are assigned to each sheltering type
h, a vector elements h_j	Percentage of housing units in each housing structure category
H, a matrix elements H_{ij}	Percentage of each housing structure category which are assigned to each sheltering type

The sheltering in a population center, **c** (a vector whose elements are the number of people in light, medium, heavy, and open categories), is calculated by:

$$\mathbf{c} = p\left\{e\mathbf{Oo} + s\mathbf{s} + (1-e-s)\left[(1-d)\mathbf{Hh} + \begin{pmatrix}0 & 0 & \cdots & d\end{pmatrix}^T\right]\right\}.$$

For clarity, this can be written with expanded notation as:

$$\begin{pmatrix} c_1 \\ c_2 \\ \vdots \\ c_i \end{pmatrix} = p\left\{ e \begin{pmatrix} O_{11} & O_{12} & \cdots & O_{1j} \\ O_{21} & O_{22} & \cdots & O_{2j} \\ \vdots & \vdots & & \vdots \\ O_{i1} & O_{i2} & \cdots & O_{ij} \end{pmatrix} \begin{pmatrix} o_1 \\ o_2 \\ \vdots \\ o_j \end{pmatrix} + s \begin{pmatrix} s_1 \\ s_2 \\ \vdots \\ s_i \end{pmatrix} + \right.$$

$$\left. \left(1-e-s\right) \left[\left(1-d\right) \begin{pmatrix} H_{11} & H_{12} & \cdots & H_{1k} \\ H_{21} & H_{22} & \cdots & H_{2k} \\ \vdots & \vdots & & \vdots \\ H_{i1} & H_{i2} & \cdots & H_{ik} \end{pmatrix} \begin{pmatrix} h_1 \\ h_2 \\ \vdots \\ h_k \end{pmatrix} + \begin{pmatrix} 0 \\ 0 \\ \vdots \\ d \end{pmatrix} \right] \right\}$$

where there are i sheltering categories (in this study, four: light, medium, heavy, and open), j occupational categories, and k housing structure categories. Consider a simple example: assume that all people at risk are working and that there are only two occupation categories, office workers and farmers. Also, assume that office workers are always in buildings, and may be in light, medium or heavy sheltering with equal probability (33% in each). Farmers, on the other hand, are usually outside, say 75 percent of the time, and in light structures the remaining 25 percent of the time. If there are 1,000 people in the population center, and 40 percent of the people are farmers and 60 percent are office workers, then the following equation can be stated:

$$\begin{pmatrix} c_{Light} \\ c_{Medium} \\ c_{Heavy} \\ c_{Open} \end{pmatrix} = 1000 \text{ people} \left\{ (100\% \text{ at work}) \left(\begin{array}{c|cc} & \mathit{Office} & \mathit{Farmers} \\ \hline \mathit{Light} & 33\% & 25\% \\ \mathit{Med} & 33\% & 0\% \\ \mathit{Heavy} & 33\% & 0\% \\ \mathit{Open} & 0\% & 75\% \end{array} \right) \begin{pmatrix} 60\% \text{ office} \\ 40\% \text{ farmers} \end{pmatrix} \right\}$$

which results in:

c_{Light}= 1,000 * 100% * (33% * 60% + 25% * 40%) = 300 people in light structures,
c_{Medium}= 1,000 * 100% * (33% * 60% + 0% * 40%) = 200 people in medium structures,
c_{Heavy}= 1,000 * 100% * (33% * 60% + 0% * 40%) = 200 people in heavy structures, and
c_{Open}= 1,000 * 100% * (0% * 60% + 75% * 40%) = 300 people in the open.

The following sections describe the methods used to determine the values for the variables in Table 4-1.

Some of the variables, particularly *d*, *s*, and *e*, vary with season and time of day. In this study, four scenarios were analyzed: night, weekend days, winter weekdays, and summer weekdays. The sheltering was determined for each of these scenarios for each population center.

4.3.1 Total Population Counts

The population was obtained from the 2000 U.S. Census (U.S. Census Bureau 2000) for California, Nevada, Oregon, Washington, Idaho, Montana, and Alaska. Where the population density is relatively low and in areas where the vehicle is closer to the ground, population centers with smaller area are necessary for the risk calculation to have sufficient accuracy. In this study, census tracts were used as the population centers close to the landing area. For other areas, especially where the population density is large, census tracts are unnecessarily small (and increase computing time dramatically). In this study, "places," as defined by the census, are used as the population centers for intermediate distances and counties are used for the largest distances. For Canada, the population data was obtained from the Canadian Census (Statistics Canada 1996), but no sheltering information was available, so all people were assumed to be in the open. Approximately 3,000 population centers were used in the analysis.

4.3.2 Sheltering from Housing

The 1990 U.S. Census (U.S. Census Bureau 1990) includes data for the "number of housing units in structure." [3] For each housing unit in the census, this datum indicates the size of the building of which the housing unit is a part. This datum can be used as a proxy to determine the sheltering categories for people at home. The mapping from structure type to sheltering category was estimated from experience gathered from more detailed surveys in the vicinity of Vandenberg AFB and Cape Canaveral Air Station. The average number of floors was estimated for each structure type based on the premise that structures with more units are more likely to have more floors. Sheltering levels were assigned as follows: the top floor of any housing structure as “light,” the next two floors as “medium,” and lower floors as “heavy.” With this rule, the sheltering percentage mapping was determined, and is shown in Table 4-2.

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[3] The U.S. Census Bureau releases the data from each census in stages. This study was performed after the initial release of data from the 2000 census, but before the full release. The 2000 housing, employment, and school data were not yet released at the time of this analysis.

Table 4-2
Relationship Between Sheltering Categories and Census Housing Structure Categories

Census category	Stories (Average)	Light	Medium (Percent)	Heavy
1-detached	1.2	83.3	16.7	0.0
1-attached	1.2	83.3	16.7	0.0
2 units	1.4	71.4	28.6	0.0
3 or 4	1.8	55.6	44.4	0.0
5 to 9	2.2	45.5	90.9	0.0
10 to 19	2.6	38.5	76.9	0.0
20 to 49	4.0	25.0	50.0	25.0
50 +	6.0	16.7	33.3	50.0
Mobile home	1.0	100.0	0.0	0.0
Other	1.3	76.9	23.1	0.0

The percentage of unsheltered home population (people outside) was estimated for four scenarios: 1 percent in the open at night, 30 percent on weekend days, and 20 percent on weekdays in the summer, and 10 percent on weekdays in the winter.

4.3.3 Sheltering Due to School

The number of people enrolled in preprimary, elementary, or high school was taken from the 1990 census. This was divided by the total number of people in the region (in 1990) to determine the percentage of people in school. This percentage was used in the weekday winter scenario. In the other scenarios, 5 percent of this value was used for summer weekdays (due to year-round schools and summer school), 2 percent on weekends, and 0 percent at night.

The sheltering from schools was determined from assumptions and typical building practices. It was assumed that 15 percent of the school population is in the open (e.g., outside for lunch, recess, breaks), and that schools in this area average one and one-half stories, leading to 56.7 percent in light sheltering and 28.3 percent in medium sheltering.

4.3.4 Sheltering Due to Employment

The percentage of the population working was determined from the 1990 U.S. Census data. The census tabulates a matrix of how many people were employed as a function of two variables: the number of hours worked per week and the number of weeks worked per year. The employment percentage was then determined by (hours/40) x (weeks/52) x (100 percent), as shown in Table 4-3.

Table 4-3
Usage of the Census Data on Employment

Employment category	Employed %
35 or more hours per week:	
50 to 52 weeks	100.0
48 to 49 weeks	94.2
40 to 47 weeks	84.6
27 to 39 weeks	65.4
14 to 26 weeks	38.5
1 to 13 weeks	11.5
15 to 34 hours per week:	
50 to 52 weeks	62.5
48 to 49 weeks	58.9
40 to 47 weeks	52.9
27 to 39 weeks	40.9
14 to 26 weeks	24.0
1 to 13 weeks	7.2
1 to 14 hours per week:	
50 to 52 weeks	17.5
48 to 49 weeks	16.5
40 to 47 weeks	14.8
27 to 39 weeks	11.4
14 to 26 weeks	6.7
1 to 13 weeks	2.0

The census provides the number of people in each of these employment categories. The total employment percentage was determined by taking the sum of the number of people times the employment percentage in each category, and dividing by the total population. The percentage of people actually at work, however, varies by scenarios. In this study, 5 percent of the employment percentage was used at night, 90 percent for weekdays in both summer and winter, and 20 percent on weekends.

In order to determine sheltering from employment, the best available data in the census is the number of people in each occupation. This study used the mapping from occupation to sheltering category shown in Table 4-4.

Table 4-4
Mapping Between Occupation and Sheltering Categories

Managerial and Professional Specialty Occupations	Heavy	Medium (Percent)	Light	Open
Executive, administrative, and managerial occupations	50	25	25	0
Professional specialty occupations	25	50	25	0
Technical, sales, and administrative support occupations				
Technicians and related support occupations	50	25	25	0
Sales occupations	25	25	25	25
Administrative support occupations, including clerical	33	33	33	0
Service occupations				
Private household occupations	0	15	85	0
Protective service occupations	25	25	25	25
Service occupations, except protective and household	30	30	30	10
Farming, forestry, and fishing occupations	0	0	25	75
Precision production, craft, and repair occupations	33	33	33	0
Operators, fabricators, and laborers				
Machine operators, assemblers, and inspectors	25	25	25	25
Transportation and material moving occupations	0	0	50	50
Handlers, equipment cleaners, helpers, and laborers	25	25	25	25

4.3.5 On-base Population

In a study for the X-33 vehicle, Baeker *et al.* (1999) determined the sheltering on Edwards AFB. The location of people is more precise than those that can be determined from the census. The sheltering data from that study was incorporated into the sheltering database for this study, with the corresponding census tracts removed. The Baeker population model does not differentiate by scenario, so the same sheltering was used for all scenarios.

4.4 RISK TO GROUND BASED POPULATION

This section presents the results of the analysis of risk to ground based populations and other sensitive assets. Risk to ground based populations is expressed in the form of casualty expectation, the expected number of persons who may be severely or fatally injured (Abbreviated Injury Scale level 3 or greater) (Association for the Advancement of Automotive Medicine [AAAM] 1998; Haber and Der Avanesian 2000). Two standards for acceptable risk to ground populations are applicable: the Range Commanders Council criteria (RCC 321-00, 2000) and the Range Safety Requirements of the Eastern and Western Range (EWR 127-1, 2000). The RCC standard states a maximum for *fatality* expectation, whereas the EWR standard states a maximum for *casualty* expectation. The guideline for both standards is the same numerical value, 30 x 10^{-6} (30 per million missions). Risks in this report have been expressed in casualty expectation, as this is a more stringent standard.

Since a major objective of this study was to assess which azimuths are potentially acceptable LEV entry azimuths, we have adopted entry descent risk as a function of azimuth as the fundamental presentation of the results of the analysis. In the following material, risks are first presented for a baseline reference case for each azimuth. Subsequent sections present parametric evaluations of the sensitivity to various modeling assumptions using a reduced set azimuths. The assumptions were evaluated separately to limit the number of cases to be evaluated. In addition, at the end, a “worst case” scenario is computed, based on the assumption that the maximum risk levels for each parameter are linearly additive. This ignores possible synergism of parameter effects and limitations of unrealistic combinations.

The following values were used for the baseline reference risk analysis:

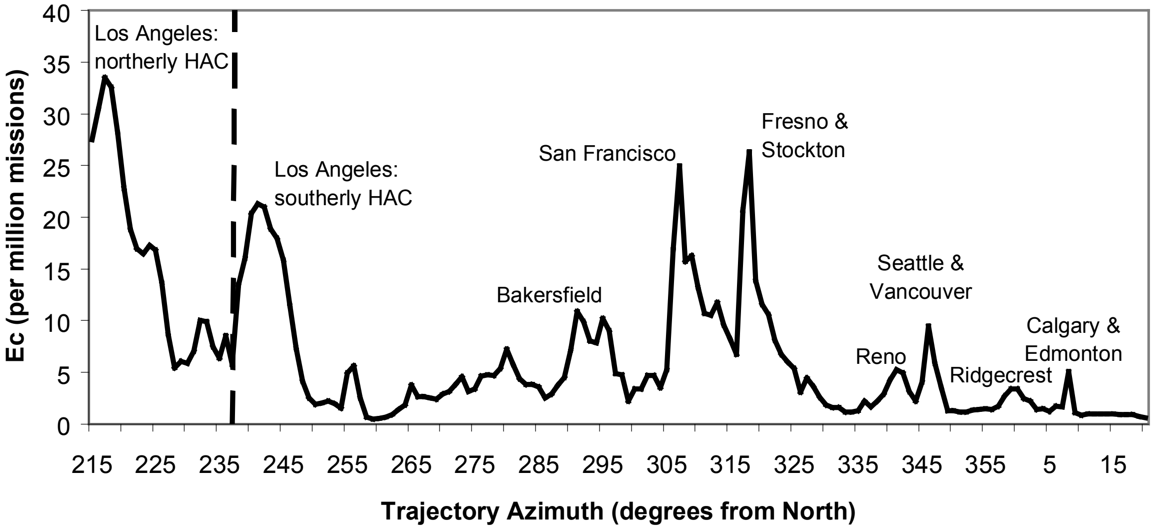
• Breakup	Vehicle breaks into seven pieces
• Cross-track uncertainty at 650 nautical miles (NM) from Edwards AFB	$\sigma_{cr} = 3$ NM
• Sheltering	Weekday summer sheltering[4]
• Atmospheric data (Wind density profile, wind uncertainty)	June
• Failure probability	3×10^{-3} (3 in 1,000)

4.4.1 E_C as a Function of Azimuth

Figure 4-7 depicts descent casualty expectation as a function of azimuth for the reference case. The figure shows that when overflight of the Los Angeles basin is avoided, calculated risks are less than the Eastern and Western Ranges allowable value of casualty expectation, 30×10^{-6} (30 per million). Indeed, for many trajectories, the risk is less than 5×10^{-6} (5 per million).

---

[4] Weekdays during the summer was selected as the baseline case because it has a higher risk than the other scenarios (except weekend days which represent a smaller fraction of the year).



Note : HAC crossover marked with dashed line; place names identify overflown regions making major contributions to risk.

Figure 4-7 Reference Case of E_C versus Azimuth

Several features of this figure are worth noting. The first set results from one of the modeling assumptions. Recall that the transition from the straight-line trajectory to the HAC was always selected to assure that the LEV flew along the HAC for a minimum of 180°. Therefore, the trajectories at 237 and 238 degrees are not simply one degree apart; these entry trajectories "end" at a different points, connecting to different HACs (see Figure 3-9). As a result, there is a discontinuity at this azimuth in the dependence on population centers overflown. In fact, there is a duplication of areas overflown within certain azimuthal ranges (e.g. the trajectory at 257 degrees is similar to 235 degrees and 258 degrees is similar to the one at 236 degrees). Thus, for example, the shape of the casualty expectation curve to the left of the HAC transition (215 to 236 degrees) is similar to its shape immediately to the right of the transition (242 to 258 degrees). The total casualty expectation for the two sets of trajectories differs because of the risk to the on-base population and the nearby off-base populations (Lancaster).

The figure (see also Figure 4-12) also identifies the relationship between high-risk azimuths and regions overflown making significant contributions to these risks:

Regions of Concern	**High-Risk Azimuths**
Edge of the Los Angeles Basin	218 and 245
Bakersfield	294
San Francisco Bay Area	308
Fresno and Stockton	318
Reno/Sparks, Nevada	340
Seattle and Vancouver	351
Ridgecrest (near Edwards AFB)	Small broad rise centered at 358
Calgary and Edmonton	008

For most azimuths, the contribution to the risk from on-base population is small. The maximum on-base E_C is (for the reference case) is only 5 x 10^{-6} (5 per million). The on-base population contributes most significantly in the range of azimuths (265°–280°) where risks from other population centers are small. In this range, the on-base population contributes up to 75 percent of the total risk, so preventative measures could reduce the risk in these azimuths even further. However, these azimuths are already among the safest azimuths, other than polar routes, so it is probably unnecessary. There is one significant caveat to all analysis of risk to on-base population: the risks are highly dependent on the exact geometry of the HAC.

4.4.2 Trajectory Uncertainty

Increased crossrange uncertainty in the trajectory increases the ground area placed at risk and decreases the peak risk levels. In the limit, if the crossrange trajectory uncertainty were eliminated, the region at risk would follow an extremely narrow band about the instantaneous impact point (IIP). Risks within this narrow band would be unrealistically high; risks outside the band would be understated. The crossrange uncertainty, in effect, causes the risk across a band of azimuths to be "averaged." In this study, the trajectory crossrange standard deviation was fixed at the HAC intercept at 0.5 NM. The effect on calculated risk of increasing the standard deviation at a range of 650 NM to 6 NM and the effect of decreasing the standard deviation at that range to 1 NM was investigated (for other distances, the uncertainty is linearly proportional to remaining flight time before the HAC intercept). Figure 4-8 shows the effect of varying the modeled crossrange uncertainty.

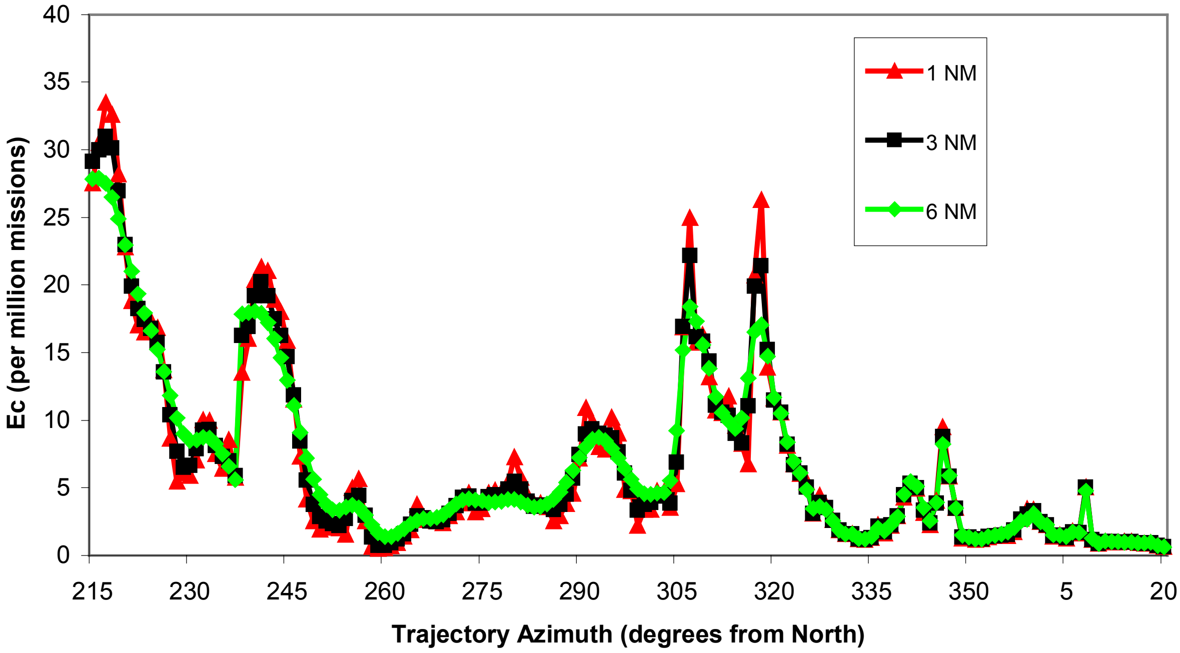


Figure 4-8 Effect of Cross-Range Dispersion on E_C

The effect of the variation is relatively small over the range of azimuths investigated. The greatest effect occurs near the azimuths associated with peak levels of risk. The risks associated with the 1 NM crossrange standard deviation resulted in somewhat higher and sharper risk peaks than the reference case. The 6 NM crossrange standard deviation resulted in lower, flatter risk peaks.

4.4.3 Sheltering Scenarios

Figure 4-9 shows the casualty risk for the four different sheltering scenarios, night, summer weekdays, winter weekdays, and weekend days.

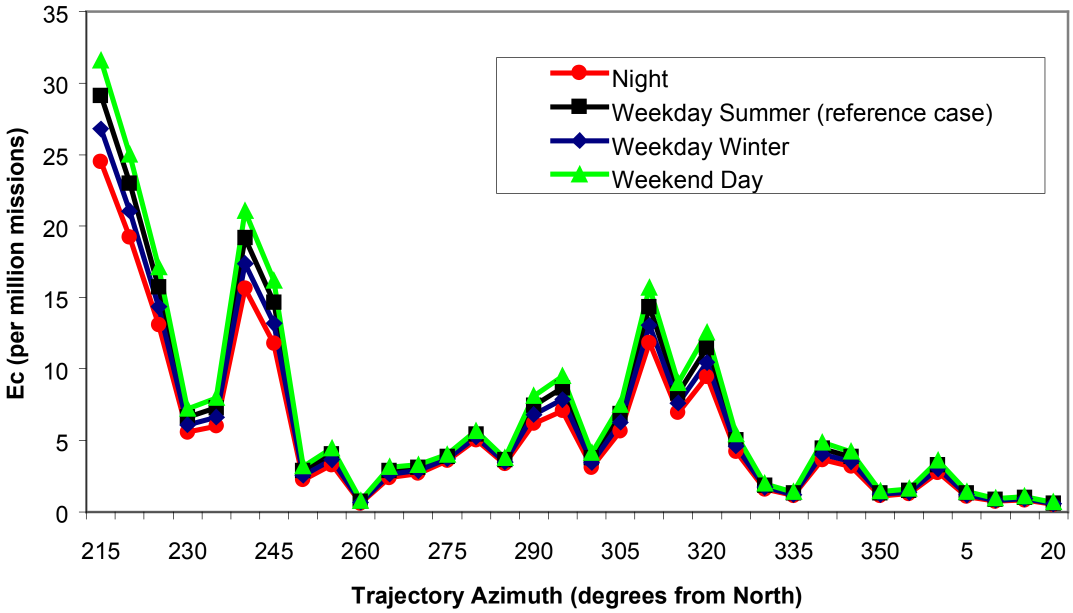


Figure 4-9 Effect of Sheltering Scenario on E_C

The nighttime sheltering scenario is consistently the lowest risk scenario, whereas weekend day sheltering levels are the highest risk. Weekdays are between these extremes, with summer having higher risk than winter. However, the risk on weekend days exceeds the risk of the weekday summer case (the reference case) by a maximum of only 11 percent.

4.4.4 Seasonal Atmospheric Variations

The atmosphere changes depending on the season, in terms of wind pattern, profile, and uncertainty and atmospheric density. Figure 4-10 shows the effects of these different conditions for four different months: March, June, September, and December.

The effects vary by azimuth, since the primary effect is that the different wind profiles alter the impact areas for the low ballistic coefficient fragments. Most of the risk is accrued from failures that occur when the LEV is relatively high; descent into the lower atmosphere occurs relatively close to the HAC. Consequently, wind effects are far less significant than would be experienced for a launch vehicle. The highest risk case is only 27 percent higher than the reference case at any azimuth.

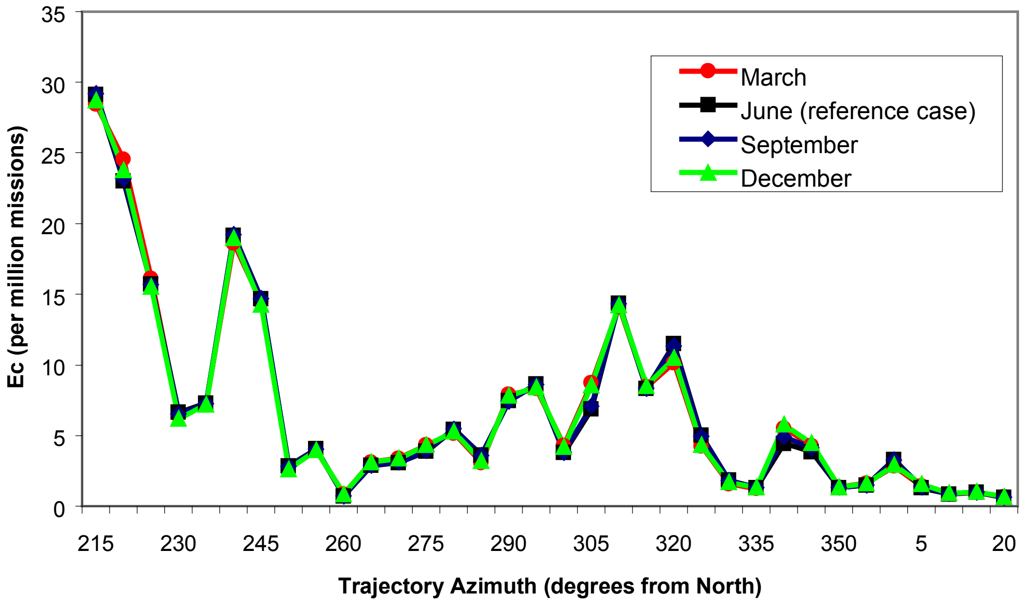


Figure 4-10 Effect of Seasonal Atmospheric Changes on E_C

4.4.5 Debris Characterization

The different breakup modes can result in different risks because of the properties of the falling fragments and the interaction with sheltering. Note that the two postulated modes specified are quite similar. The largest breakup fragment in the case where the vehicle breaks up has properties very similar to those of the intact vehicle. The largest fragment is responsible for most of the risk. Figure 4-11 shows dependence of risk upon the breakup mode.

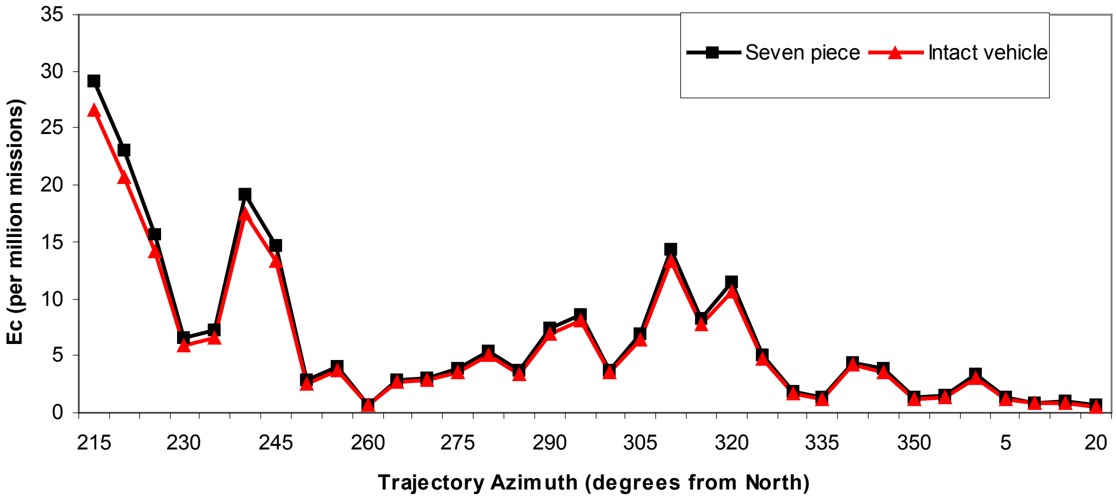


Figure 4-11 Effect of Different Breakup Modes on E_C

Since the two modes are quite similar, the effect is small and the risks from an intact vehicle never exceeds the risk from the breakup case. It is possible that the properties of a specific LEV could be different enough that higher risk could be apparent. An LEV configured to allow low angle (with respect to the horizontal) impacts would place substantially larger areas at risk if allowed to impact intact.

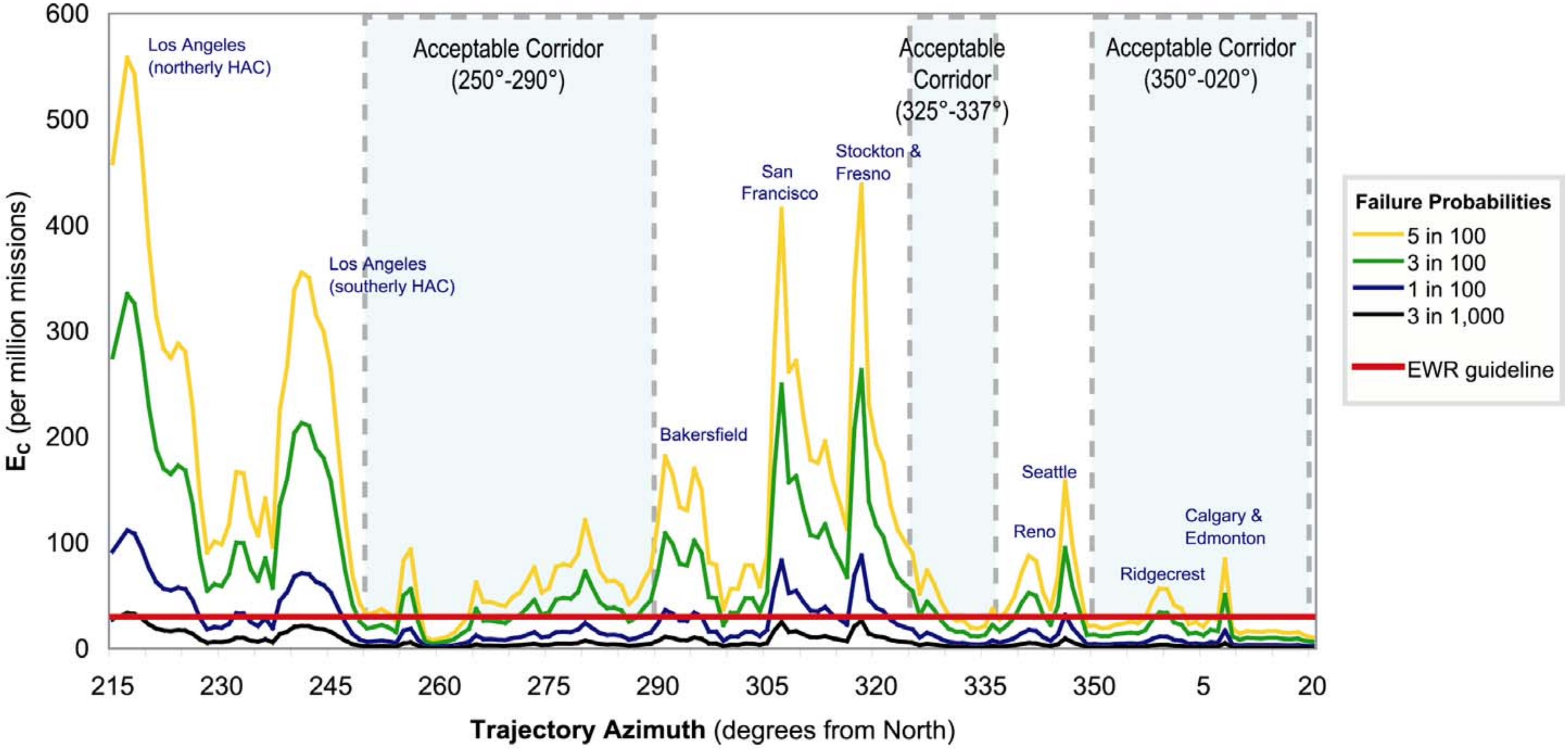
4.4.6 Parameterized by Failure Probability

The previous parametric analyses were based on the assumed descent failure probability of 3×10^{-3} (3 in 1,000). If the four parameters investigated are linearly additive, then the "worst case" risk is 40 percent higher than the results for the reference case.

Figures 4-12 and 4-13 show the effect of failure probability on the computed risk for the reference case and the "worst case" scenarios for the following failure probabilities:

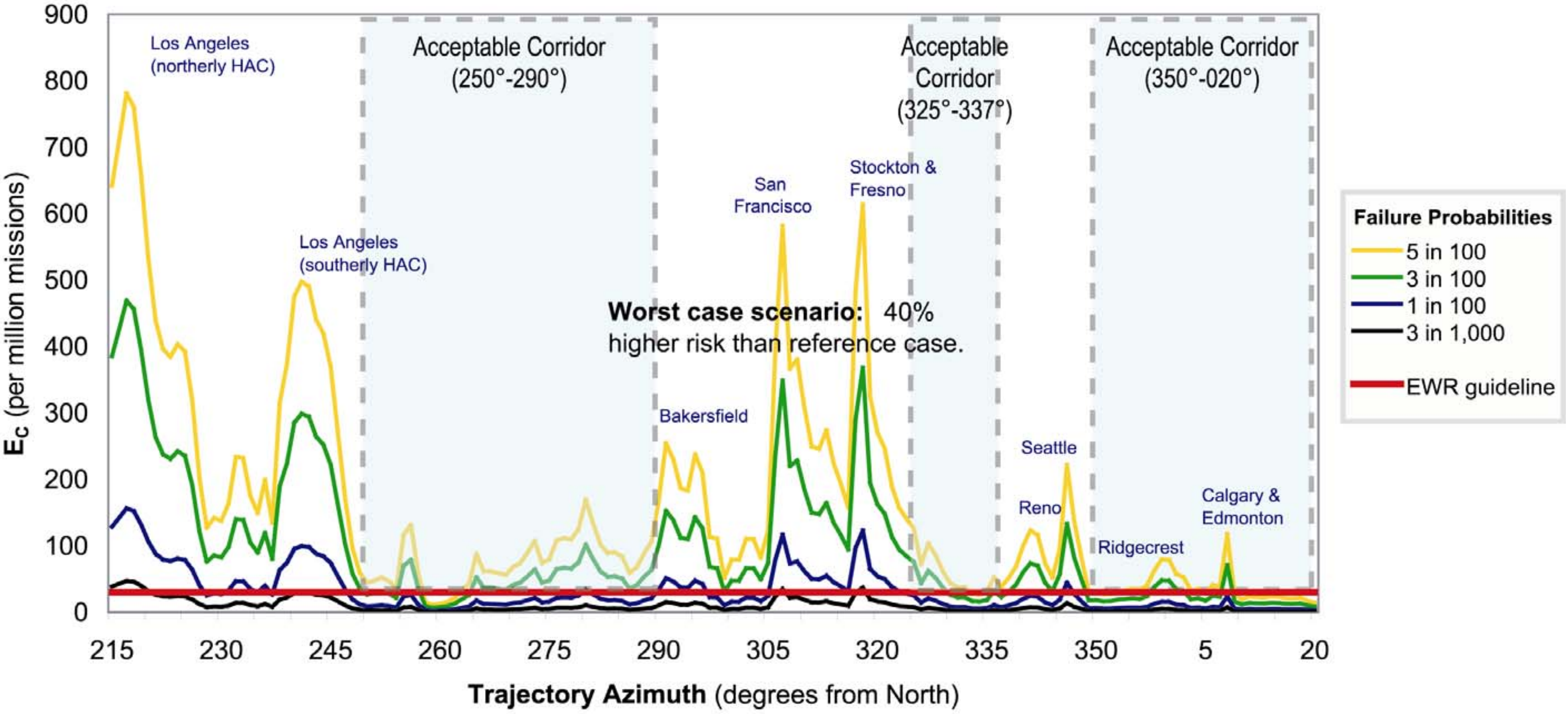
- 3×10^{-3} (3 in 1,000) reference failure probability;
- 3×10^{-2} (3 in 100) upper bound failure probability;
- 5×10^{-2} (5 in 100) corresponds to suggested success probability of 95 percent; and
- 1×10^{-2} (1 in 100) corresponds to suggested success probability of 99 percent.

The guideline established by the Eastern and Western Ranges of a maximum collective risk of 30×10^{-6} (30 in one million) casualties is also indicated for reference.



Note: Place names identify overflown regions making major contributions to the risk.

Figure 4-12 E_C Versus Azimuth for Different Failure Probabilities (Baseline Parameters)

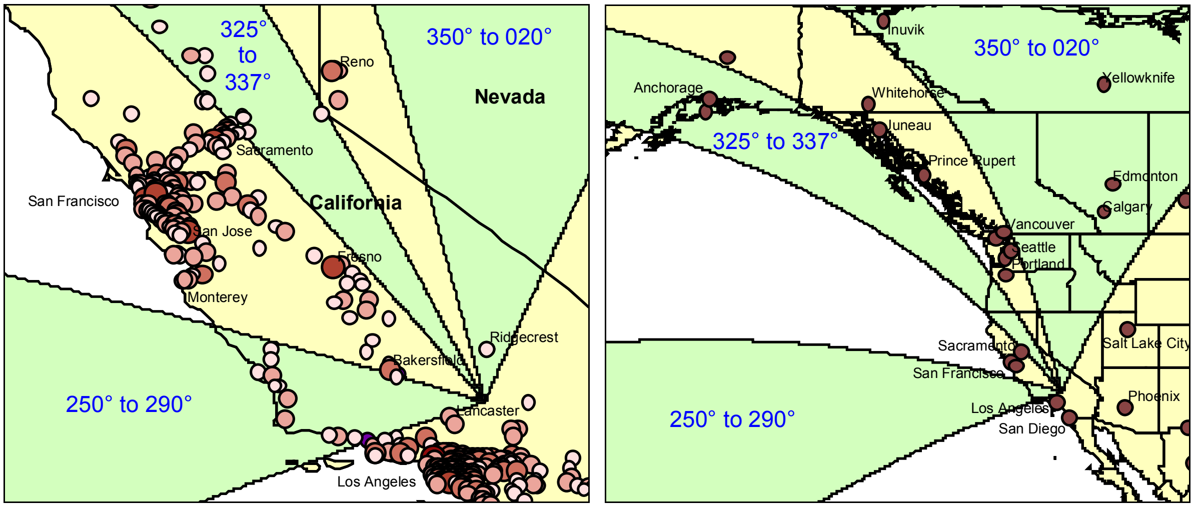


Note: Place names identify overflown regions making major contributions to the risk.

Figure 4-13 E_C Versus Azimuth for Different Failure Probabilities (Worst Case Scenario)

4.5 CONCLUSIONS

The probability of failure is extremely important in determining the feasibility of a flight due to safety concerns. If a vehicle has a failure probability greater than 3 x 10^{-2} (3 in 100), then only very narrow corridors are available for flight. However, if the vehicle has a failure probability less than 1 x 10^{-2} (1 in 100)(1 percent), trajectories following a wide range of azimuths have risk levels below the casualty expectation established by the Eastern and Western Ranges (EWR 127-1, 2000). Based on this study of risk to ground population, trajectories with azimuths from 250 degrees to 290 degrees are recommended. In addition, trajectories with azimuth from 325 to 337 are recommended as an alternate corridor. Trajectories with azimuth from 350 degrees to 020 degrees are recommended for entry from polar orbits. Figure 4-14 shows the acceptable reentry corridors and population centers for the study area.


325° to 337°
350° to 020°
Reno
Nevada
Sacramento
California
San Francisco
San Jose
Fresno
Monterey
Ridgecrest
Bakersfield
250° to 290°
Lancaster
Los Angeles
Inuvik
350° to 020°
Yellowknife
Anchorage
Whitehorse
Juneau
325° to 337°
Prince Rupert
Edmonton
Calgary
Vancouver
Seattle
Portland
Salt Lake City
Sacramento
San Francisco
Phoenix
250° to 290°
Los Angeles
San Diego

Note: Corridors shown in green; population shown by red points.

Figure 4-14 Maps of Acceptable Reentry Corridors

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5.0 RISK OF AIRCRAFT DEBRIS COLLISION

Calculating the risk of debris collision with aircraft uses the same fundamental method for determining the risk of casualties to ground level populations. CRTF computations of debris probability densities must be combined with a model of air traffic spatial density. Moreover, the problem is somewhat more complicated for three reasons. First, instead of determining impact probabilities on a 2-dimensional surface, the collisions can occur within a 3-dimensional volume. Second, aircraft move at a speed comparable to (or faster than) the speed at which the debris falls, which increases the risk. Third, no aircraft density dataset exists with spatial resolution comparable to the census.

The solution to the first two problems is included in an extension to CRTF. The probability of impact from debris is dependent on the debris information and the position, altitude, size, and velocity of the airplane. The probability of impact with airplanes was mapped for many planes traveling parallel to the earth's surface, leading to a three-dimensional map of the risk of collision.

The only data available on airplane distribution in the sky are sector data. This does not provide good geographical resolution, as the sectors are relatively large (approximately 5,000 NM^2). Another, more complete, dataset with more geographic resolution is the number of landings at every airport. However, landings do not directly give information on airborne aircraft locations or how long airplanes are airborne. Therefore, in this study, a simulation method was used to create a model of air traffic density based on the landing data. The model was then corroborated by comparison with the sector data and by consultation with an aviation expert.

To determine the risk to aircraft, models of the probability of impact with a single airplane and airplane density were developed as a function of three-dimensional position for several classes of airplanes. Five classes of aircraft were used: single-engine, multi-engine, turboprop, private jet, and commercial jet. The models of impact probability and air traffic density were combined to determine the total risk of collision for possible LEV trajectories.

5.1 AIRCRAFT-DEBRIS COLLISION MODEL

The collision between two moving bodies depends on the velocities and dimensions of the two bodies. Define the velocity of the aircraft as $\mathbf{v}_a$, the velocity of the debris as $\mathbf{v}_d$, the characteristic length of the debris as x_d, and the length, width, and height of the airplane as l, w, and h respectively. It is useful to define the angle φ as the orientation of the relative velocity vector of the debris and aircraft with respect to the local vertical. This angle is given by

$$\varphi = \tan^{-1} \frac{|\mathbf{v}_a|}{|\mathbf{v}_d|}.$$

For simplicity, it assume that the debris falls vertically and the aircraft flies horizontally.

For a single aircraft, the volume in which a collision occurs is the volume of space swept out by the aircraft in the time it takes the debris to fall the height of the aircraft. The time of the fall is

$$t_{fall} = \frac{x_d + h}{|\mathbf{v}_d|}.$$

The volume swept out by the aircraft must be determined from area of the aircraft as viewed from the fragment. An area of collision for plan view is

$$A_{PLAN} = (l + x_d)(w + x_d)$$

The front area of collision is

$$A_{FRONT} = (w + x_d)(h + x_d)$$

For an airplane, which is not a simple box, the plan and front areas can be defined more carefully based on the actual areas of the airplane. The area of the aircraft from the perspective of the debris is

$$A_{sweep} = A_{FRONT} \cos\varphi + A_{PLAN} \sin\varphi \, .$$

The collision volume is the volume of the airplane plus the volume swept out by the aircraft moving for time t_{fall},

$$V_{collision} = l\, w\, h + A_{sweep} \left|\mathbf{v}_a\right| t_{fall} \, .$$

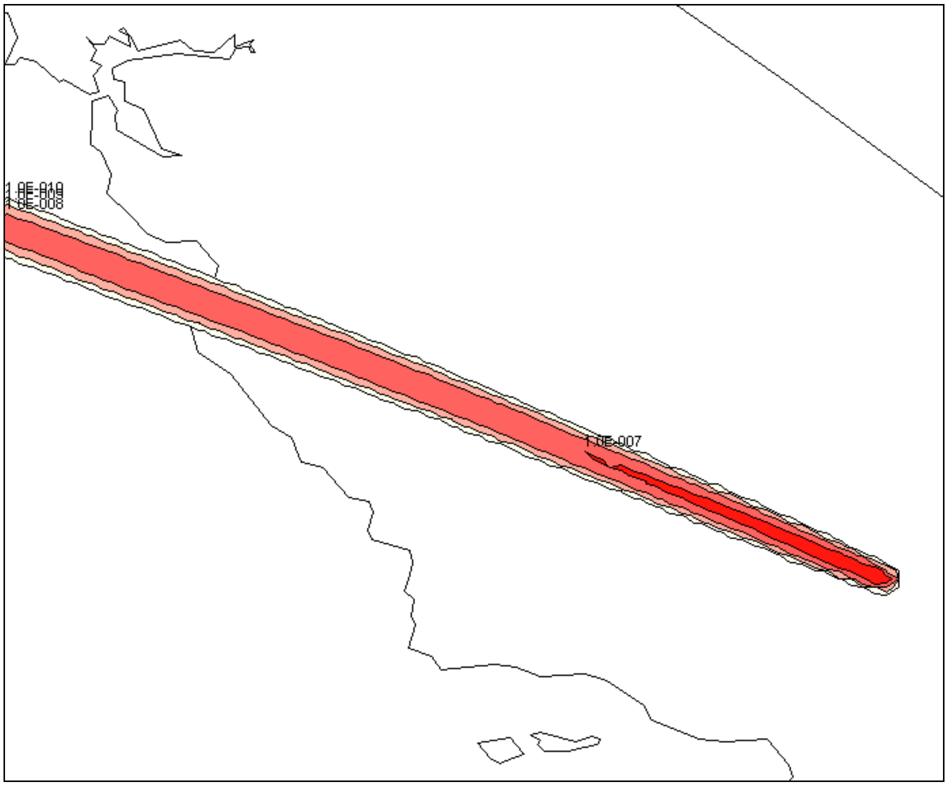
The probability of debris impacting a single airplane is the collision volume multiplied by the probability density of debris at that point:

$$P_I(x, y, z) = V_{collision}\; d_{debris}(x, y, z) \, .$$

The probability density of debris was calculated by CRTF from the sum of all the distributions of debris from each breakup state vector. By calculating the probability of impact with airplanes for many combinations of breakup state vectors and aircraft different positions and altitudes, $P_I(x, y, z)$ can be determined for each type of airplane.

The map of impact probability density has a similar shape for all classes of airplanes at all altitudes; only the magnitude of the impact probability density varies. $P_I(x, y, z)$ is highest for commercial jets at low altitudes, because the speed of the airplane is much greater than that of the fragment (so a large volume is swept out). In addition, the impact probability density is quite similar for all LEV trajectories when rotated around the HAC intercept point; minor variations are caused by the different orientations of the effective wind direction with respect to the horizontal component of the LEV velocity vectors. Figure 5-1 shows a map of $P_I(x,y,z = 2{,}400\text{ ft})$ for the 293-degree azimuth trajectory and a commercial jet aircraft.

As is true for the probability of impact on the ground, the aircraft debris collision probabilities are larger near the landing point, because the debris footprint is moving across the ground more slowly than when the LEV is further away. The maximum probability of collision at any point outside of Edwards AFB is less than one collision per million catastrophic mission failures. In most regions, the probability is less than one collision per ten million failures. The RCC standard states that no airplanes may fly in a region where the risk from a mission is greater than $1\text{x}10^{-7}$ (1 in 10 million)(RCC 2000). For any mission with a descent failure probability of less than 10 percent (assuming a constant failure rate along descent), the aircraft exclusion zone required by this standard is within the Edwards AFB boundary. The common practice at the Eastern and Western Ranges follows a more stringent standard of $1 \text{ x } 10^{-8}$ (1 in 100 million); by this standard no exclusion zone is needed outside of Edwards AFB when the failure probability is less than one percent.



Note: Conditional probability of collision with an aircraft given a failed LEV.

Figure 5-1 P_I(x, y, z=2400 feet) for a Commercial Jet

5.2 FAA SECTOR DATA

The FAA high altitude sectors (airspace above 24,000 feet above MSL) in the region of interest are shown in Figure 5-2. The FAA provided data on the traffic in these sectors.

Detailed information, listing each flight tracked by the FAA in one 24-hour period was obtained from the Los Angeles and Oakland Air Route Traffic Control Centers (ARTCCs) (FAA Oakland, FAA Los Angeles). Each listing included the time the airplane entered and exited the sector, the altitude, and the category, as well as other data. An excerpt of these data is shown in Table 5-1. These data enabled analysis of a number of parameters to develop an estimate of the air traffic density.

The data elements provided were

- Flight identifier (AID);
- Time the flight entered and exited the sector (ENTRY TIME and EXIT TIME);
- The method by which the airplane entered and exited the sector (ENTRY MEANS and EXIT MEANS);
- The category of the flight (CATEGORY, which can be air carrier, military, air taxi, or general aviation);

- The make and model of the aircraft (AIRCRAFT TYPE);
- The originating and destination airports (ORIG and DEST); and
- The altitude (FLIGHT LEVEL is altitude divided by 100).

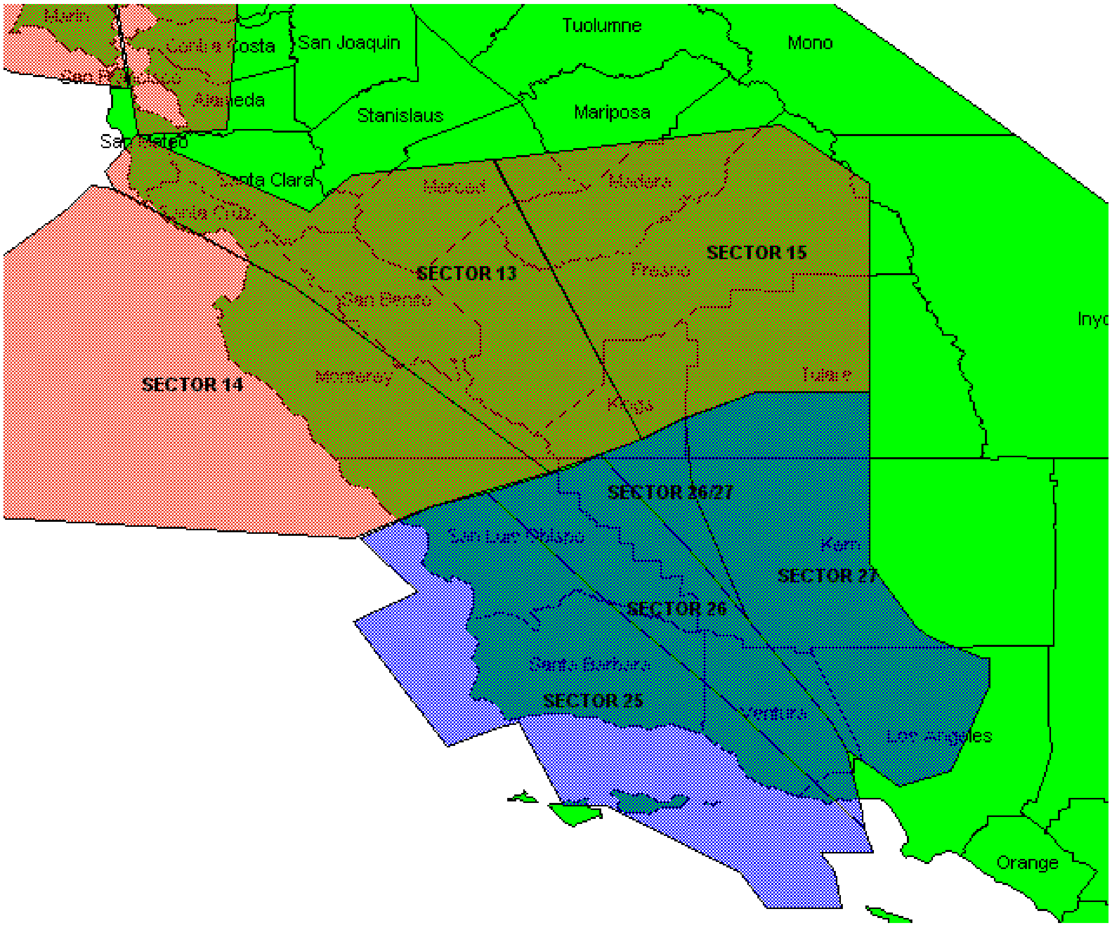

Marin
Contra Costa
San Joaquin
Tuolumne
Mono
San Francisco
Alameda
Stanislaus
Mariposa
San Mateo
Santa Clara
Merced
Madera
Santa Cruz
SECTOR 13
SECTOR 15
Fresno
San Benito
Iny
SECTOR 14
Monterey
Tulare
Kings
SECTOR 26/27
San Luis Obispo
Kern
SECTOR 27
SECTOR 26
Santa Barbara
SECTOR 25
Ventura
Los Angeles
Orange

Figure 5-2 FAA High Altitude Sectors

Table 5-1
Example: Sector Data from the FAA

AID	ENTRY TIME	EXIT TIME	ENTRY MEANS	EXIT MEANS	CATE GORY	AIRCRAFT TYPE	ORIG	DEST	FLIGHT LEVEL
FDX1892	1315	1321	FM-S25	TO-S14	A/C	B72Q	OAK	LAX	330
UAL2410	1318	1331	FM-S03	TO-ZCO	A/C	B733	ONT	SFO	310
OPT623	1322	1333	FM-S03	TO-ZCO	MIL	CL60	VNY	SFO	290
SWA450	1327	1334	START	TO-S13	A/C	B737	OAK	LAX	370

Figure 5-3 shows the instantaneous airborne count (IAC) of aircraft for an example sector for each hour. The IAC is calculated by summing the number of minutes every airplane flew in the sector in each hour and dividing by 60. There is a distinct pattern: there are no airplanes flying between 11:00 p.m. and 5:00 a.m. (local time), and there is a relatively consistent number between 7:00 a.m. and 10:00 p.m.

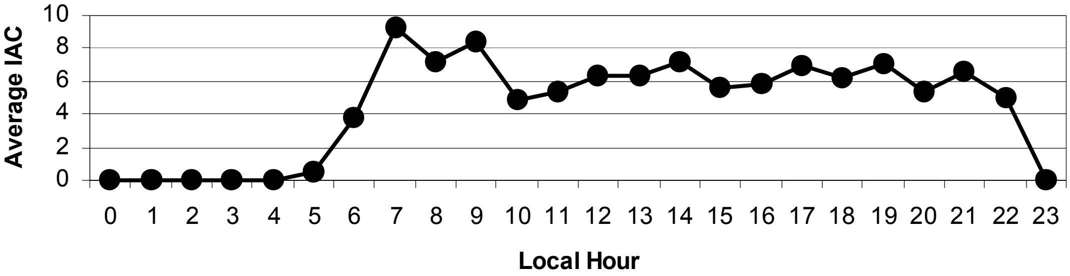


Figure 5-3 Average Instantaneous Count of Aircraft in Sector 13 by Hour

Table 5-2 shows that this observation is consistent for all the sectors. Therefore, two models of aircraft density are necessary, one for day and one for night and such a model is sufficient.

Table 5-2
Average Instantaneous Count Statistics for All Sectors

	Sector					
	13	**14**	**15**	**25**	**26**	**27**
Average 7am -10pm	6.6	4.7	6.5	7.8	4.9	7.3
Standard deviation	1.2	1.2	1.0	1.6	0.7	1.1
Coefficient of variation (%)	17.9	26.4	15.4	20.0	15.3	14.8
Total count 12am to 5am	0	0	0	0	0	0

5.3 DENSITY MODEL

The most comprehensive data set for estimating aircraft spatial density is the number of landings at each airport by flight category. These are available for towered airports from the FAA Air Traffic Data System (FAA ATADS 2001) and for all airports from AirNav.com (AirNav 2001). The data from the two sources is in reasonably good agreement for towered airports, so in this study, the more complete dataset from AirNav.com was used. These landing counts were used to estimate the aircraft spatial density as described below. The density was estimated by modeling typical flight paths and using the landing data to determine the appropriate temporal and spatial distribution. The first step in the process is to model a single flight path with reasonable flight parameters. Then, many flight paths are simulated with varied parameters. For each class of aircraft, the flight paths are summed to produce axisymmetric distributions as a function of distance from an airport and altitude. Finally, a three-dimensional air traffic density model for the region of interest is determined by superimposing the distributions weighted according to the landing data. This results in a three-dimensional probability density function of aircraft in the sky.

5.3.1 Single Flight Model

The flight path of an airplane is the three-dimensional position of the airplane as function of time from takeoff, $\mathbf{r}(t)$. This is modeled in two portions: takeoff to halfway to the destination and halfway to the destination through landing. In order to make this modeling tractable, the effect of winds on flight paths was neglected. Position, as a function of time, was obtained by integrating the velocity, $\mathbf{v}(\mathbf{r})$,

$$\mathbf{r}(t) = \int_0^t \mathbf{v}(\mathbf{r}(t'))\, dt'$$

Several variables must be known to model the full flight path: the velocity vector as function of position, the total flight time, T, and the final destination azimuth relative to the runway, ϕ_d. The velocity vector can be estimated from several parameters that are characteristics of aviation practices and classes of airplanes, which are shown in Table 5-3.

Table 5-3
Parameters Used in Simulating a Single Aircraft Flight

Parameter	Typical units	Variable
Cruise speed	Knots	v_m
Cruise altitude	Feet	a_m
Climb rate	Feet/minute	r_c
Climb speed	Knots	v_c
Approach speed	Knots	v_d
Descent angle	Degrees	θ_d
Turn rate (inverse of time for 360^o turn)	Degrees/minute	ϕ_t
Lowest altitude of turn on ascent	Feet	a_a
Lowest altitude of turn on descent	Feet	a_d

After a minimum turn altitude has been reached, the airplane is allowed to turn to a new heading to allow for a destination being along a different azimuth than the runway. For ease of calculation, a coordinate system can be defined with the x-axis along the runway axis, the z-axis in the vertical direction, and $\hat{\mathbf{y}} = \hat{\mathbf{z}} \times \hat{\mathbf{x}}$. The current airplane heading can be defined as:

$$\phi = \tan^{-1} \frac{v_y}{v_x}.$$

For an airplane taking off, the following equations are used determine the velocity as a function of position. They are integrated as a function of time from 0 to half the total trip length. From the runway until the turn altitude is reached ($r_z = a_a$), the velocity components are given by:

$$v_x = v_c$$
$$v_y = 0$$
$$v_z = r_c$$

Then velocity components are updated at a time interval, *dt*, until the destination azimuth is reached ($\phi = \phi_d$), the velocity components are

$$
\begin{aligned}
v_x &= v_c \cos(\phi + \phi_t dt) \\
v_y &= v_c \sin(\phi + \phi_t dt) \\
v_z &= r_c
\end{aligned}
$$

Then until the cruise altitude is reached ($r_z = a_{\max}$), the velocity components are given by:

$$
\begin{aligned}
v_x &= v_c \cos(\phi_d) \\
v_y &= v_c \sin(\phi_d) \\
v_z &= r_c
\end{aligned}
$$

For the remainder of the first half of the flight, the velocity components are

$$
\begin{aligned}
v_x &= v_m \cos(\phi_d) \\
v_y &= v_m \sin(\phi_d) \\
v_z &= 0
\end{aligned}
$$

The landing path is described by beginning with touchdown and moving backward. Similar equations are used and the takeoff and landing paths are calculated simultaneously. The primary difference is that the approach speed is only used at very low altitudes (unlike the climb speed, which was used for all altitudes). For landings, from the runway until the turn altitude is reached ($r_z = a_d$), the velocity components are given by:

$$
\begin{aligned}
v_x &= v_d \cos(\theta_d) \\
v_y &= 0 \\
v_z &= v_d \sin(\theta_d)
\end{aligned}
$$

Then, until the destination azimuth is reached ($\phi = \phi_d$), the velocity components are

$$
\begin{aligned}
v_x &= v_m \cos(\phi + \phi_t dt) \\
v_y &= v_m \sin(\phi + \phi_t dt) \\
v_z &= v_m \sin(\theta_d)
\end{aligned}
$$

A small inaccuracy is introduced by using the speed v_m as the horizontal speed (ignoring the contribution due to vertical movement), but this is a small factor, much less than the error associated with the input parameters.

Until the cruise altitude is reached ($r_z = a_{\max}$), the velocity is

$$
\begin{aligned}
v_x &= v_m \cos(\phi_d) \\
v_y &= v_m \sin(\phi_d) \\
v_z &= v_m \sin(\theta_d)
\end{aligned}
$$

For the remainder of the take-off half of the flight, the velocity is

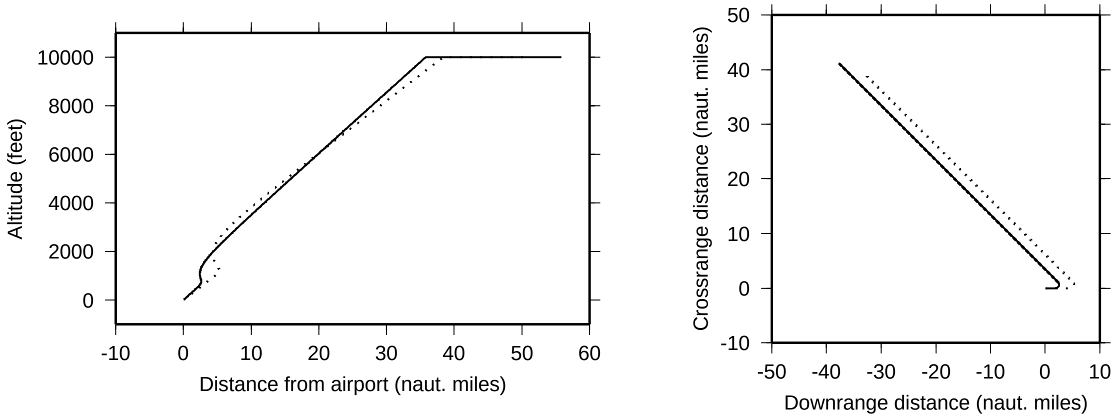
$$
\begin{aligned}
v_x &= v_m \cos(\phi_d) \\
v_y &= v_m \sin(\phi_d) \\
v_z &= 0
\end{aligned}
$$

Representative parameters for a typical single engine airplane are listed in Table 5-4.

Table 5-4
Example: Parameter Values for a Single-Engine Aircraft

Parameter	Value
Cruise (maximum) speed	120 knots
Cruise altitude	10,000 feet
Climb rate	500 feet/minute
Climb speed	100 knots
Approach speed	80 knots
Descent angle	3 degrees
Turn rate (a “two-minute turn”)	180 degrees/minute
Lowest altitude of turn on ascent	500 feet
Lowest altitude of turn on descent	1,000 feet
Total flight time	1 hour
Azimuth of destination relative to runway	180 degrees

Figure 5-4 shows the flight path simulation results for an airplane with these parameters. The wiggle in altitude/distance plot results from the destination of the airplane being in a different direction than takeoff. The airplane takes off in the direction of the runway, begins a turn at 500 feet, and ends the turn when it has reached a heading of 135 degrees from the runway.



Note: Solid line is takeoff path; dashed line is landing.

Figure 5-4 Single Aircraft Flight Profiles from Simulation

5.3.2 Single Airport Model for Each Airplane Class

Route variations were included in the modeling by sampling from the ranges of the key parameters. By simulating many flights, the density of airplanes relative to an airport can be mapped. Some of the parameters are treated as common to all types of airplanes, as shown in Table 5-5.

Table 5-5
Parameters Common to All Airplanes

Parameter	Minimum	Standard	Maximum
Descent angle (degrees)	2.5	3	3.5
Turn rate (minutes / 360 turn)	3	2	1.5
Lowest altitude of turn on ascent (feet)	300	500	700
Lowest altitude of turn on descent (feet)	500	1,000	1,500
Azimuth of destination relative to runway (degrees)	0	-	180

For the other parameters, ranges of reasonable values can be estimated for each of the five classes of airplanes: single-engine, multi-engine, turboprops, private jets, and commercial jets. Model results are relatively insensitive to the values of these parameters—parameter errors as much as 25 percent will not significantly affect the results. These ranges were derived from two on-line aviation databases (*Aviation Week* 2001; Rising Up 2001), with advice from Jerry Chafkin (Chafkin 2001).

Common single-engine airplanes are the Cessna 172/175 and the Beech Bonanza. Table 5-6 shows parameters for this class of airplanes for transient flights (flights from one airport to another).

Table 5-6
Flight Parameters for Single Engine Airplanes on Transient Flights

Parameter	Minimum	Standard	Maximum
Cruise speed (knots)	90	120	180
Cruise altitude (feet)	5,000	10,000	20,000
Climb rate (feet/min)	300	500	900
Climb speed (knots)	80	90	100
Approach speed (knots)	40	60	80
Flight time (hrs)	0.5	1	4

Single-engine airplanes performing local operations were also modeled. Local operations are flights which take-off and land at the same airport and stay within 10 nautical miles of the airport. Most commonly, they are training flights. While these flights may last longer than the indicated flight time, this is the average flight time per landing (of which there may be several in a flight). Table 5-7 shows the parameters for these local flights.

Table 5-7
Flight Parameters for Single Engine Airplanes on Local Flights

Parameter	Minimum	Standard	Maximum
Cruise speed (knots)	90	120	150
Cruise altitude (feet)	2,000	3,000	4,000
Climb rate (feet/min)	300	500	900
Climb speed (knots)	80	90	100
Approach speed (knots)	40	60	80
Flight time	5 min	10 min	30 min

Common twin-engine airplanes are the Cessna 310, the Beech Baron, and the Piper Navajo. Table 5-8 shows the parameters used for this class of airplanes.

Table 5-8
Flight Parameters for Multi Engine Airplanes

Parameter	Minimum	Standard	Maximum
Cruise speed (knots)	170	195	230
Cruise altitude (feet)	10,000	20,000	28,000
Climb rate (feet/min)	750	1,000	1,500
Climb speed (knots)	120	150	170
Approach speed (knots)	60	80	100
Flight time	30 min	1 hr	4 hrs

Table 5-9 shows the parameters used for turboprop aircraft based on the Beech KingAir.

Table 5-9
Flight Parameters for Turboprop Airplanes

Parameter	Minimum	Standard	Maximum
Cruise speed (knots)	225	325	375
Cruise altitude (feet)	15,000	22,000	30,000
Climb rate (feet/min)	900	1,400	2,000
Climb speed (knots)	150	180	200
Approach speed (knots)	95	120	140
Flight time	30 min	1 hr	4 hrs

Common types of general aviation jets are the Cessna Citation and the Learjet. Table 5-10 shows the parameters used for this class of airplanes:

Table 5-10
Flight Parameters for General Aviation Jets

Parameter	Minimum	Standard	Maximum
Cruise speed (knots)	400	450	600
Cruise altitude (feet)	30,000	38,000	45,000
Climb rate (feet/min)	1,500	2,000	3,000
Climb speed (knots)	300	350	400
Approach speed (knots)	100	130	150
Flight time	30 min	1 hr	4 hrs

Common types of commercial jets are the DC-10 and the Boeing 727. Table 5-11 shows the parameters used for this class of airplanes:

Table 5-11
Flight Parameters for Commercial Jets

Parameter	Minimum	Standard	Maximum
Cruise speed (knots)	450	550	650
Cruise altitude (feet)	28,000	33,000	40,000
Climb rate (feet/min)	1,500	2,000	3,000
Climb speed (knots)	350	400	450
Approach speed (knots)	100	130	150
Flight time	30 min	1.5 hrs	6 hrs

Based on the above parameters, two dimensional density models for each class were calculated. The density d_{2D} is a function of distance *r* and altitude *a* relative to the airport. The value of $d_{2D}(r,a)$ is the average number of seconds that airplanes are in each distance/altitude cell per landing divided by the volume of the cell. The density is calculated by running simulations and totaling the time the airplanes spent in each cell. These models, based on 10,000 simulated flights for each class, are shown in Figure

5-5. The models combine both takeoff and landing segments of the flight. Each of the density models has a similar shape, but the relative values depend on the above parameters.

There are no airplanes directly above the airport, because when the airplanes turn, they do not fly directly over the top, however, when the aircraft density contributions from many airports are superposed they provide density contributions to the airspace over airports. The single airport aircraft density plots also show no airplanes at low altitudes beyond some distance from the airport, because airplanes are flying at the cruising altitude. The near airport pattern is a cone shape, connecting the airport to the cruising altitudes.

For most classes of airplane, there is a shallower slope for airplanes climbing and a steeper slope for airplanes descending. For the single engine airplanes, the climb and descend paths blend because the cruising speed of the airplanes is not much larger than the climb speed.

A limitation of this model is that it treats all destination directions from the airport as equally likely (axisymmetric). This is not true at some airports, such as those near the ocean, where it is much less likely for a airplane to fly out to sea. However, a much more complex and computationally intensive model would be required to remove this simplification. The three-dimensional model provides insight into the errors that might result from this simplification.

5.3.3 Creating a Three-dimensional Aircraft Density Model

To create a three-dimensional model for each class of airplane, the two-dimensional models are superimposed for every airport. The contributions of the two-dimensional models to the three-dimensional model are weighted by the number of landings, *l*, at each airport:

$$d_{3D}(x,y,z)=\sum_{i=1}^{N_{airports}} d_{2D}\left(\sqrt{\left[(r_i)_x-x\right]^2+\left[(r_i)_y-y\right]^2},(r_i)_z-z\right)l_j ,$$

where $\mathbf{r}_i$ is the location of the airport. The location of all airports was obtained from the Bureau of Transportation Statistics (BTS Rural 2001).

For most airports, the distribution of transient flights by aircraft type corresponds to the distribution of the aircraft types based at the airport. For example, if there are 100 landings/day at an airport, and 50 percent of the based airplanes have are single-engine, 40 percent are multi-engine, and 10 percent are jets, then it is assumed that 50 of the landings are by single-engine airplanes, 40 by multi-engine, and 10 by jets. Military flights were excluded from the study because their contribution to the overall density is small and developing adequate models would have involved extensive modeling including classified information. Also, it was clear from the data that the distribution of aircraft based at the airports did not correspond to the flight distribution for large commercial airports. For these airports, the aircraft type distribution was estimated from the flight categories (air carrier, air taxi, general aviation). For all airports, local flights were assumed to be single-engine aircraft.

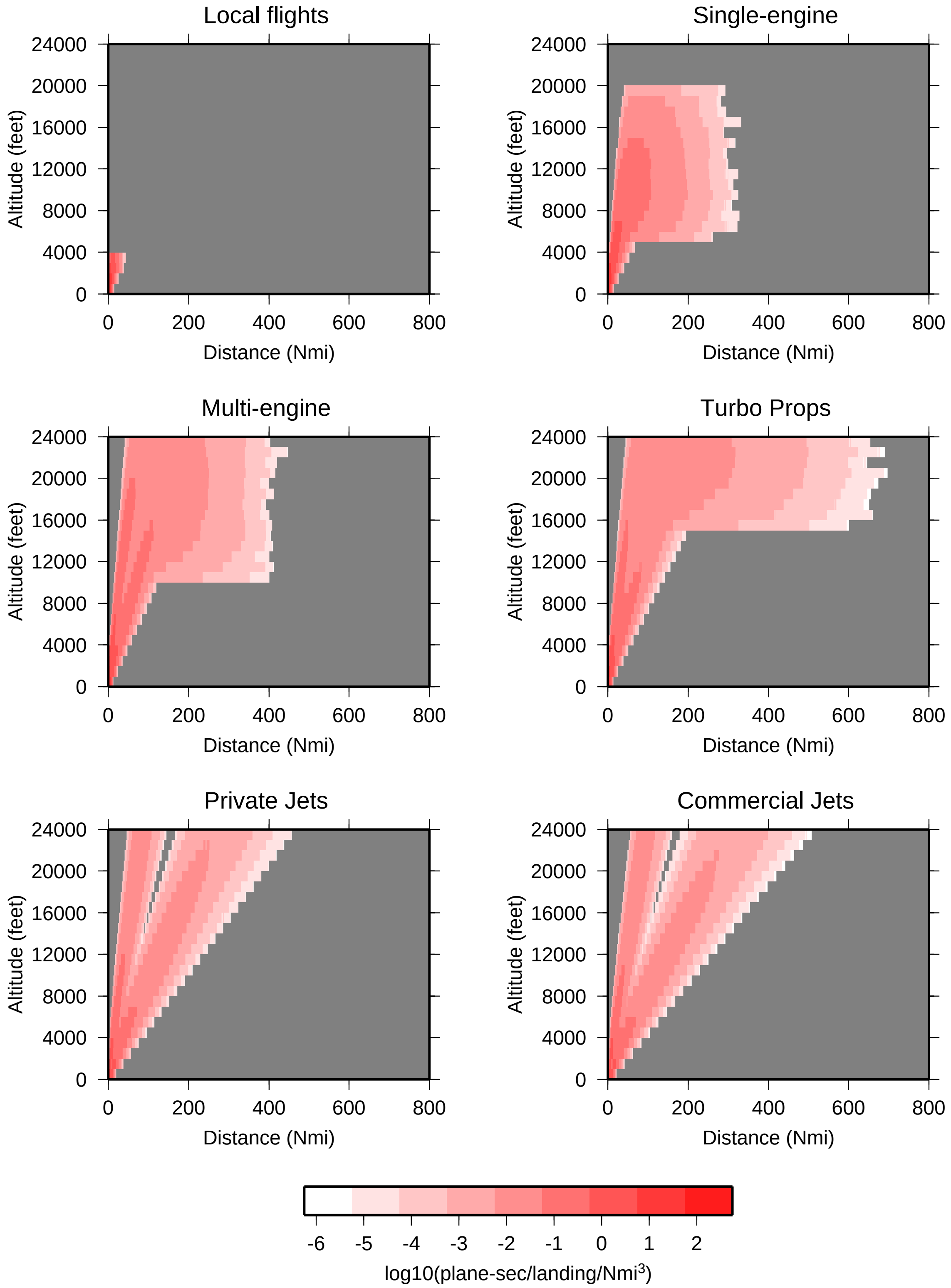


Figure 5-5 Two-Dimensional Density Models for Each Airplane Class Relative to Airport

Figure 5-6 shows the combined the three-dimensional models for all classes of airplanes at a number of altitudes. This illustrates that most airplanes are quite close to the ground; the maximum density at 2,400 feet is over 100 times the maximum density at 16,800 feet. This occurs for a number of reasons. Many airplanes fly relatively short trips and fly at cruising altitude for a short period of time. Also, airplanes fly more slowly while climbing and during final descent, so more of the flight time is spent at lower altitudes. The most important factor, however, is that most airplanes are small, single-engine craft that never reach higher altitudes.

The figures show that the modeled axisymmetric distribution relative to each airport is not a significant factor. Although the model over-predicts the number of airplanes over the ocean, this is a small fraction of the total number of airplanes, and does not significantly impact the results.

The model was validated by comparison with the IAC data from the previous section. The IAC for a region can be determined by integrating the density over the volume of the region. This integration has been carried out for the sectors for which data was available and the results are shown in Table 5-12.

Table 5-12
Instantaneous Airborne Count: Model vs. Data

	Sector					
	13	**14**	**15**	**25**	**26**	**27**
Data (from Table 5-2)	6.6	4.7	6.5	7.8	4.9	7.3
Model prediction	10.3	8.5	3.5	13.2	8.9	17.3

The model somewhat over-predicts the number of airplanes in most sectors. With the exception of sector 15, the relative values match quite well. For this study, the model appears to be a conservative estimate of the number of airplanes in the sky, and is accurate within an order of magnitude.

In addition the methodology and results of the model were discussed with Jerry Chafkin, the former director of the Federal Aviation Administration Pacific Region (Chafkin 2001). He assisted in identifying the best sets of parameters for different aircraft classes. In addition, he noted that a typical IAC for the Los Angeles basin is 150 to 200. While this includes all altitudes, the horizontal extent of this region was not clearly defined. Depending on the size of the region chosen, the model predicts an IAC of 150 to 300 for the Los Angeles basin. This good agreement indicates the model may be even more accurate at lower altitudes. However, for this study, the model is assumed to be correct within an order of magnitude, and more likely over-predicts than under-predicts the air traffic.

5.4 DEBRIS COLLISION RISK RESULTS

For each class of aircraft, the expected number of impacts with debris per mission, E_I, can be calculated by integrating over all space the probability of impact multiplied by the density of airplanes, as

$$E_I^j = \iiint_{all\ space} d_{3D}^j(x,y,z)\, P_I^j(x,y,z)\, dx\, dy\, dz$$

where j is the airplane class. The total E_I for a trajectory is the sum of the E_I's of each airplane class,

$$E_I^{total} = \sum_{j=1}^{N_{classes}} E_I^j$$

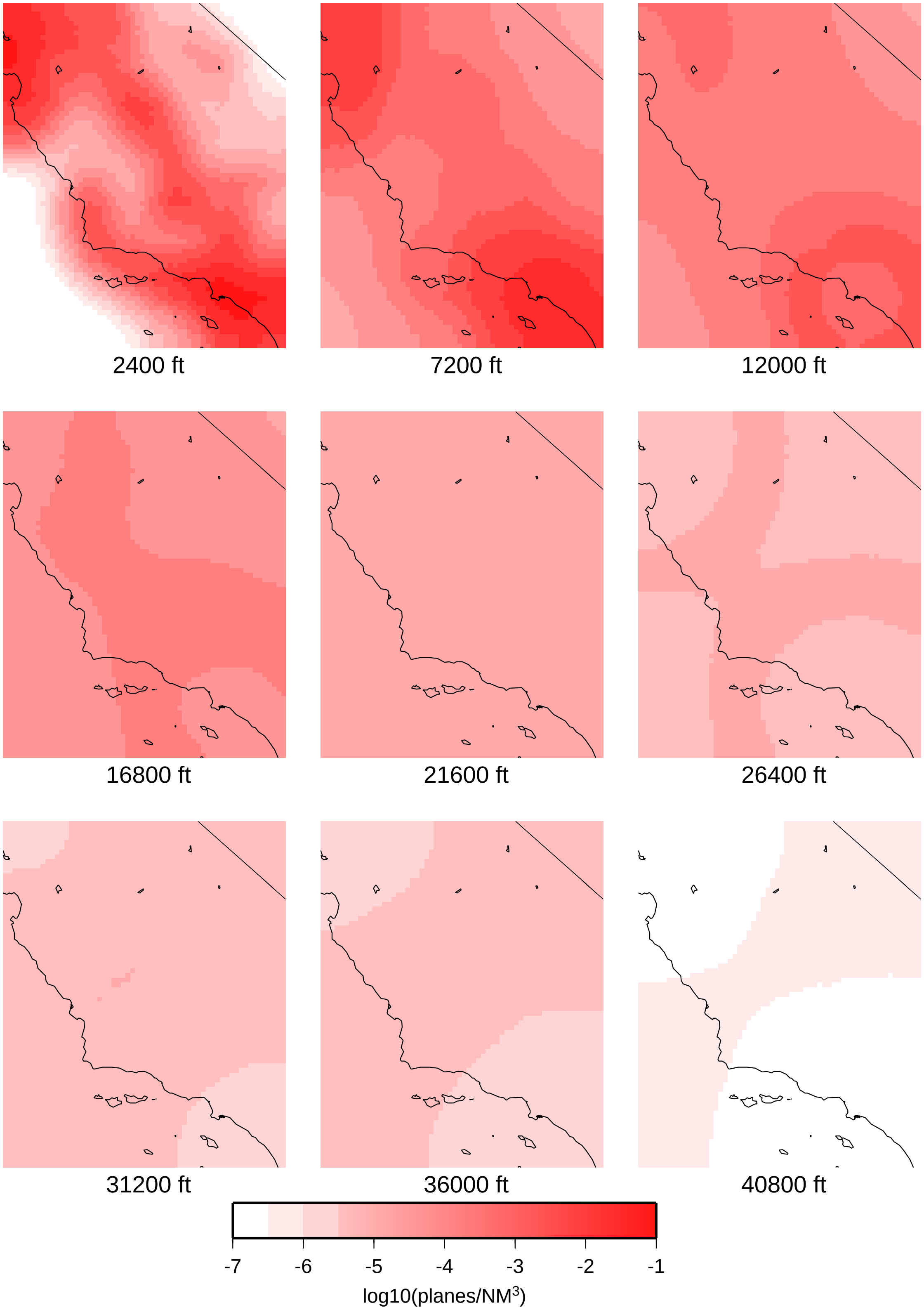

2400 ft
7200 ft
12000 ft
16800 ft
21600 ft
26400 ft
31200 ft
36000 ft
40800 ft
-7
-6
-5
-4
-3
-2
-1
log10(planes/NM³)

Figure 5-6 Three-Dimensional Model of Airplane Distribution in California

5.4.1 Aircraft Expected Number of Impacts as a Function of Azimuth

Figure 5-7 shows the total probability, using the baseline reference set of parameters outlined in the previous section, of impact to an aircraft from debris resulting from a malfunctioning LEV. The expected number of impacts is shown as a function of LEV trajectory of azimuth, assuming that there are no aircraft over Edwards AFB. Although the impact expectation was only calculated for trajectories from 215 to 320 degrees azimuth, this range has the highest density of planes, so risks for other azimuths are smaller.

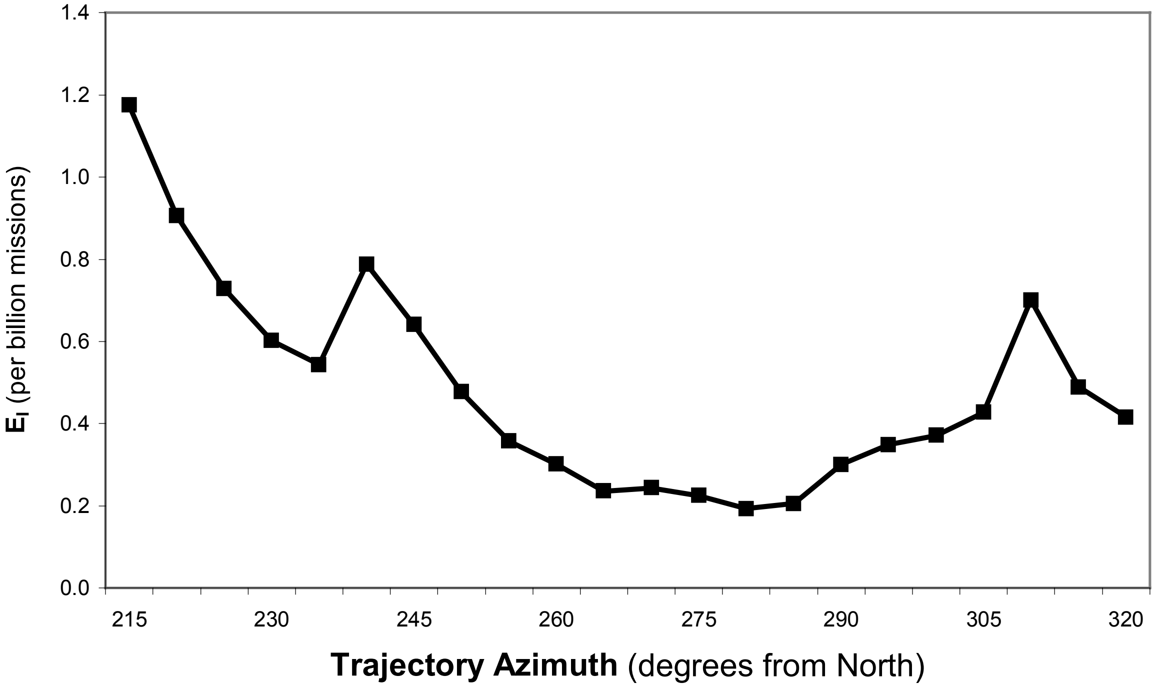


Figure 5-7 Aircraft Impact Expectation by LEV Trajectory Azimuth (Baseline Case)

The dependence of risk on LEV azimuth is substantially smoother than for the ground risk, because the aircraft risk is predominantly from Los Angeles and the San Francisco Bay Area. The total mission risk is quite low: one collision in one billion re-entries for any trajectory when the expected failure probability of 3 x 10^{-3} (3 per 1,000) is assumed.

5.4.2 Parameterized by Failure Probability

As was true for the ground risk, the probability of debris collision with aircraft is directly scalable with failure probability. Figure 5-8 shows the risk of debris collision for the following failure probabilities:

- 3 x 10^{-3} (3 in 1,000) reference failure probability;
- 1 x 10^{-2} (1 in 100) corresponds to suggested success probability of 99 percent;
- 3 x 10^{-2} (3 in 100) upper bound failure probability; and

- 5×10^{-2} (5 in 100) corresponds to suggested success probability of 95 percent.

Even for the higher probabilities of failure, the probability of debris collision is quite small for all azimuths: less than 20 collisions in one billion landings.

5.5 CONCLUSIONS

The risk of collision with aircraft is quite small; for descent failure probabilities less than 1×10^{-2} (1 in 100), the expected number of collisions is less than five per billion missions at all azimuths. In addition, based on the RCC or the EWR standards, no aircraft exclusion zones are necessary for the airspace outside of Edwards AFB.

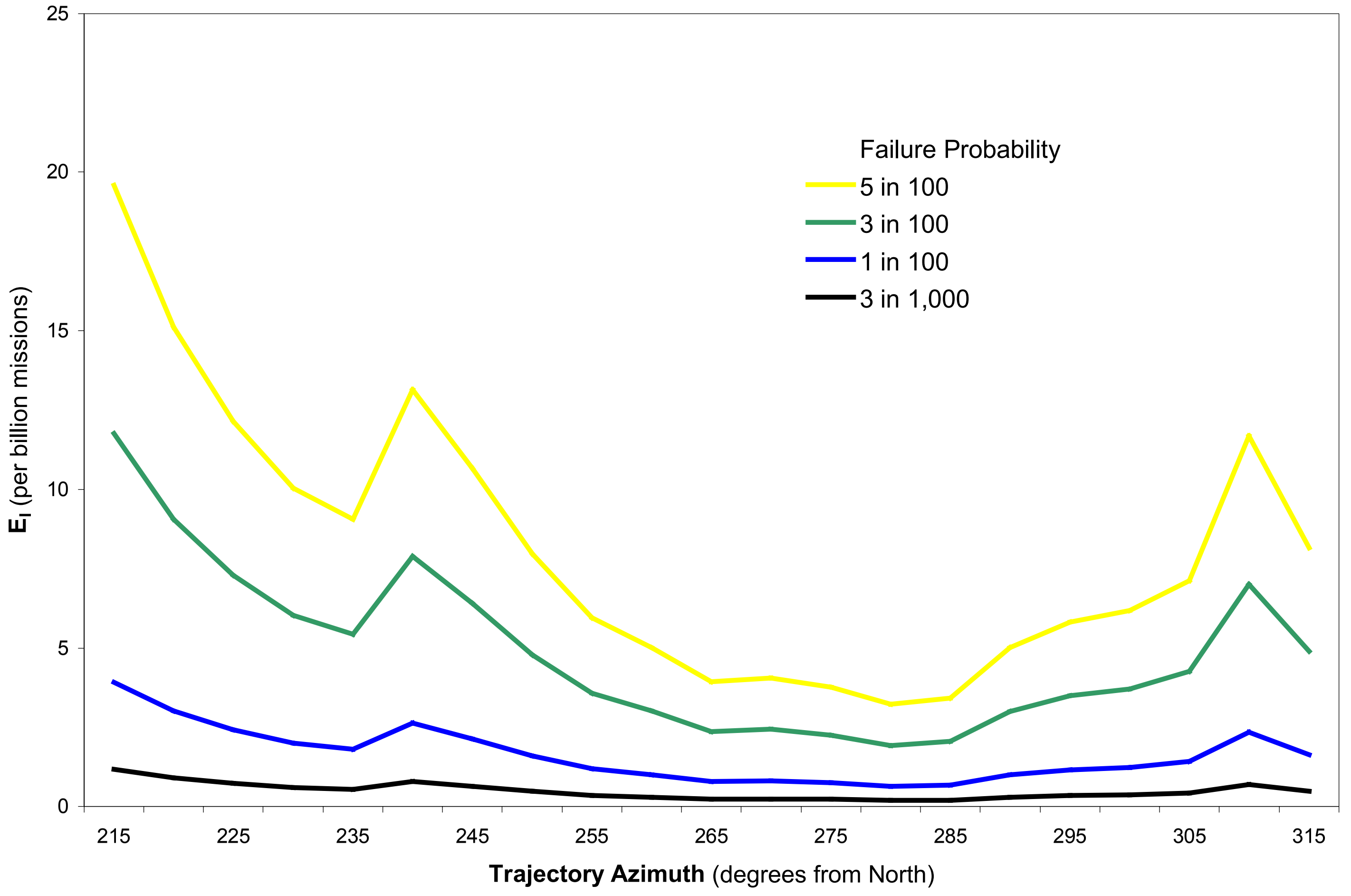


Figure 5-8 Aircraft Impact Expectation for Different Failure Probabilities

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7.0 LIST OF PREPARERS

This Quantitative Risk Analysis was prepared by Jerold M. Haber and Erik W.F. Larson of ACTA, Inc. under the direction of Tetra Tech, Inc.

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F-15A/B/C/D AIRCRAFT ENGINE EMISSIONS ESTIMATOR

Mode	Thrust Setting	Time (Min)	Time (Sec)	NOx (g/kg of fuel)	VOC (g/kg of fuel)
Start	Idle	6.3	378	993.4	3429.2
Taxi out	Idle	5.5	330	867.2	2993.8
Engine check	Military	1.1	66	394.7	68.6
Rollout	Afterburner	0.4	24	1280.6	27.8
Climbout 1	Afterburner	0.4	24	1280.6	27.8
Approach 1	Idle	1.9	114	299.6	1034.2
Approach 2	Idle	0.7	42	110.4	381.0
Landing	Idle	1.1	66	173.4	598.8
Taxi in	Idle	5.5	330	867.2	2993.8
Shutdown	Idle	0.8	48	126.1	435.5
			SUBTOTAL(g)/sortie=	**6393.4**	**11990.5**

Engine Type=	F100-100 (P&W)	**Tot. NOx (g)/sortie=**	**6393.4**	**Tot. VOC (g)/sortie=**	**11990.5**
No of Sorties/Mo=	1	**Tot. NOx (lbs)/sortie=**	**14.1**	**Tot. VOC (lbs)/sortie=**	**26.4**
No of Sortoes/Yr=	12	**Tot. NOx (lbs)/month=**	**14.1**	**Tot. VOC (lbs)/month=**	**26.4**
No of Engines=	2	**Tot. NOx (tons)/year=**	**0.1**	**Tot. VOC (tons)/year=**	**0.2**

Engine Mode	Thrust Setting	Fuel Flow	Emission Factor (NOx)	Emission Factor (VOC)
Start	Idle	0.18	7.3	25.2
Taxi out	Idle	0.18	7.3	25.2
Engine check	Military	1.30	2.3	0.4
Rollout	Afterburner	5.80	4.6	0.1
Climbout 1	Afterburner	5.80	4.6	0.1
Approach 1	Idle	0.18	7.3	25.2
Approach 2	Idle	0.18	7.3	25.2
Landing	Idle	0.18	7.3	25.2
Taxi in	Idle	0.18	7.3	25.2
Shutdown	Idle	0.18	7.3	25.2

ASSUMPTION: These numbers do not include mechanical runups of the aircraft.

SOURCE OF INFO: Air Force Engineering and Services Center (HQ AFESC/RDVS), Aircraft Engine Emissions Estimator, November 1985.

F-16A/B AIRCRAFT ENGINE EMISSIONS ESTIMATOR

Mode	Thrust Setting	Time (Min)	Time (Sec)	NOx (g/kg of fuel)	VOC (g/kg of fuel)
Start	Idle	6.3	378	162.2	157.2
Taxi out	Idle	5.5	330	141.6	137.3
Engine check	Military	1.1	66	2370.1	8.8
Rollout	Afterburner	0.4	24	485.1	1.6
Climbout 1	Afterburner	0.4	24	485.1	1.6
Approach 1	Idle	1.9	114	48.9	47.4
Approach 2	Idle	0.7	42	18.0	17.5
Landing	Idle	1.1	66	28.3	27.5
Taxi in	Idle	5.5	330	141.6	137.3
Shutdown	Idle	0.8	48	20.6	20.0
			SUBTOTAL(g)/sortie=	**3901.4**	**556.0**

Engine Type=	F100-200 (P&W)
No of Sorties/Mo=	1
No of Sortoes/Yr=	12
No of Engines=	1

Tot. NOx (g)/sortie=	**3901.4**	**Tot. VOC (g)/sortie=**	**556.0**
Tot. NOx (lbs)/sortie=	**8.6**	**Tot. VOC (lbs)/sortie=**	**1.2**
Tot. NOx (lbs)/month=	**8.6**	**Tot. VOC (lbs)/month=**	**1.2**
Tot. NOx (tons)/year=	**0.05**	**Tot. VOC (tons)/year=**	**0.01**

Engine Mode	Thrust Setting	Fuel Flow	Emission Factor (NOx)	Emission Factor (VOC)
Start	Idle	0.13	3.3	3.2
Taxi out	Idle	0.13	3.3	3.2
Engine check	Military	1.33	27.0	0.1
Rollout	Afterburner	6.52	3.1	0.01
Climbout 1	Afterburner	6.52	3.1	0.01
Approach 1	Idle	0.13	3.3	3.2
Approach 2	Idle	0.13	3.3	3.2
Landing	Idle	0.13	3.3	3.2
Taxi in	Idle	0.13	3.3	3.2
Shutdown	Idle	0.13	3.3	3.2

ASSUMPTION: These numbers do not include mechanical runups of the aircraft.

SOURCE OF INFO: Air Force Engineering and Services Center (HQ AFESC/RDVS), Aircraft Engine Emissions Estimator, November 1985.

C-130H AIRCRAFT ENGINE EMISSIONS ESTIMATOR

Mode	Thrust Setting	Time (Min)	Time (Sec)	NOx (g/kg of fuel)	VOC (g/kg of fuel)
Start	Idle	8.5	510	716.0	3855.6
Taxi out	Idle	7.5	450	631.8	3402.0
Engine check	Military	1.2	72	776.7	33.4
Rollout	Military	0.5	30	323.6	13.9
Climbout 1	Military	0.6	36	388.4	16.7
Approach 1	Idle	2.6	156	219.0	1179.4
Approach 2	Idle	1.3	78	109.5	589.7
Landing	Idle	1.2	72	101.1	544.3
Taxi in	Idle	6.4	384	539.1	2903.0
Shutdown	Idle	3.3	198	278.0	1496.9
			SUBTOTAL(g)/sortie=	**4083.3**	**14034.9**

Engine Type=	T56-15 (Allison)
No. of Sorties/Mo=	1
No of Sorties/Yr=	12
No of Engines=	4

Tot. NOx (g)/sortie=	**4083.3**	**Tot. VOC (g)/sortie=**	**14034.9**
Tot. NOx (lbs)/sortie=	**9.0**	**Tot.VOC (lbs)/sortie=**	**30.9**
Tot. NOx (lbs)/month=	**9.0**	**Tot. VOC (lbs)/month=**	**30.9**
Tot. NOx (tons)/year=	**0.1**	**Tot. VOC (tons)/year=**	**0.2**

Engine Mode	Thrust Setting	Fuel Flow	Emission Factor (NOx)	Emission Factor (VOC)
Start	Idle	0.09	3.9	21.0
Taxi out	Idle	0.09	3.9	21.0
Engine check	Military	0.29	9.3	0.4
Rollout	Military	0.29	9.3	0.4
Climbout 1	Military	0.29	9.3	0.4
Approach 1	Idle	0.09	3.9	21.0
Approach 2	Idle	0.09	3.9	21.0
Landing	Idle	0.09	3.9	21.0
Taxi in	Idle	0.09	3.9	21.0
Shutdown	Idle	0.09	3.9	21.0

ASSUMPTION: These numbers do not include mechanical runups of the aircraft.

SOURCE OF INFO: Air Force Engineering and Services Center (HQ AFESC/RDVS), Aircraft Engine Emissions Estimator, November 1985.

Process Description	Fuel Type	Manufacturer	Rate/Size	Hours/Operation	NOX	SOX	VOC	PM10
EUO Generator	Diesel	Mobile Electric	207 BHP	100/year	0.212	0.0139	0.017	0.014
EUO Generator	Diesel	Detroit	148 BHP	100/year	0.251	0.0164	0.02	0.0169
EUO Generator	Diesel	Detroit	148 BHP	100/year	0.251	0.0164	0.02	0.0169
AGE Generator	Diesel	Cummins	187 BHP	100/year	0.208	0.0137	0.017	0.0141
ICE	Diesel	Detroit	148 BHP	100/year	0.251	0.0164	0.02	0.0169
EUO Generator	Diesel	Cummins	277 BHP	100/year	0.302	0.0198	0.025	0.021
AGE AC	Diesel	Detroit	171 BHP	100/year	0.191	0.0125	0.155	0.0129
EUO Generator	Diesel	Cummins	380 BHP	100/year	0.583	0.0383	0.048	0.0397
ICE for Wind Generator	Gasoline	Ford	120 BHP	100/year	0	0	0	0
EUO Generator	Diesel	Cummins	380 BHP	100/year	0.583	0.0383	0.009	0.0396
EUO Generator	Diesel	Detroit	72 BHP	100/year	0.129	0.0109	0.01	0.009
EUO Generator	Diesel	Cummins	605 BHP	100/year	0.734	0.0483	0.06	0.0499
TOTAL Emissions in tons					**3.695**	**0.2449**	**0.401**	**0.2509**

Note:

AC	air conditioner
AGE	aerospace ground equipment
BHP	brake horsepower
ICE	internal combustion engine

DIRECT AIR QUALITY EMISSIONS

MOBILE SOURCES

Equipment or Vehicle Type	Rate of Emissions	Number of Equipment/Vehicles	Number of Miles	Number of Days	Number of Hours	NO$_x$ Emission Factor	VOC Emission Factor	PM10 Emission Factor	Total NO$_x$ Emissions[1]	Total VOC Emissions[1]	Total PM10 Emissions[1]
LDGV	lb/mile	1	50	12	N/A	0.007	0.021	0.0003	0.0002	0.0005	0.0000
LDGT	lb/mile	1	50	12	N/A	0.003	0.007	0.0002	0.0001	0.0002	0.0000
LDDT	lb/mile	1	50	12	N/A	0.004	0.002	0.001	0.0001	0.0001	0.0000
HDGT	lb/mile	1	50	12	N/A	0.010	0.006	0.0003	0.0003	0.0002	0.0000
HDDT	lb/mile	0	0	0	N/A	0.045	0.014	0.006	0.0000	0.0000	0.0000
Track Tractor	lb/hour	0	N/A	0	0	1.26	0.121	0.112	0.0000	0.0000	0.0000
Wheeled Tractor	lb/hour	0	N/A	0	0	1.269	0.188	0.136	0.0000	0.0000	0.0000
Track Loader	lb/hour	0	N/A	0	0	0.827	0.098	0.058	0.0000	0.0000	0.0000
Wheeled Loader	lb/hour	0	N/A	0	0	1.89	0.25	0.172	0.0000	0.0000	0.0000
Misc. Wheeled	lb/hour	0	N/A	0	0	1.691	0.152	0.139	0.0000	0.0000	0.0000
Gas Forklift	lb/hour	0	N/A	0	0	0.412	0.560	11.7	0.0000	0.0000	0.0000
Diesel Forklift	lb/hour	1	N/A	12	100	1.691	0.152	0.139	0.0846	0.0076	0.0070
Shipping Truck	lb/hour	1	N/A	12	100	1.691	0.152	0.139	0.0846	0.0076	0.0070
Roller	lb/hour	0	N/A	0	0	1.691	0.2	0.139	0.0000	0.0000	0.0000
Backhoe Loader	lb/hour	0	N/A	0	0	1.89	0.25	0.172	0.0000	0.0000	0.0000
Excavator	lb/hour	0	N/A	0	0	1.691	0.152	0.139	0.0000	0.0000	0.0000
Bulldozer (tracked)	lb/hour	0	N/A	0	0	24.5	2.9	12.9	0.0000	0.0000	0.0000
Haul/Concrete Truck	lb/hour	0	N/A	0	0	4.166	0.192	0.256	0.0000	0.0000	0.0000
Soil Compactor	lb/hour	0	N/A	0	0	1.691	0.2	0.139	0.0000	0.0000	0.0000
Motor Grader	lb/hour	0	N/A	0	0	0.713	0.04	0.061	0.0000	0.0000	0.0000
Frontend Loader	lb/hour	0	N/A	0	0	1.89	0.25	0.172	0.0000	0.0000	0.0000
								TOTAL:	0.1697	0.0161	0.0139

Note:

[1] Units are in tons/year.

LDGV = light-duty gasoline vehicle
LDGT = light-duty gasoline truck
LDDT = light-duty diesel truck
HDGT = heavy-duty gasoline truck
HDDT = heavy-duty diesel truck
NO$_x$ = oxides of nitrogen
VOC = volatile organic compounds
PM10 = particulate matter equal to or below 10 microns
N/A = not applicable
lb = pound

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APPENDIX C
DISTRIBUTION LIST (FINAL)

AFFTC Technical Library
412 TW/TSDL
Edwards AFB, CA 93524

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95 SPTG/SVMG
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Kern River Valley Library
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Lake Isabella, CA 93240
Attn: Karen Leifeld, Branch Supervisor

Kern County Library
Wanda Kirk Branch (Rosamond)
3611 Rosamond Boulevard
Rosamond, CA 93560

Los Angeles County Library
Quartz Hill Branch
42018 N. 50th Street W.
Quartz Hill, CA 93536

Kern County Library
Beale Memorial Library, Main Branch
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Bakersfield, CA 93301

Kern County Library
Boron Branch
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Boron, CA 93516

Native American Heritage Commission
915 Capital Mall, Room 364
Sacramento, CA 95814

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California State Clearinghouse
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Sacramento CA 95812-3044

Palmdale City Library
700 E. Palmdale Boulevard
Palmdale, CA 93550

Trona Library
82805 Mountain View St.
Trona, CA 93562

Federal Aviation Administration
Western Pacific Region
Attn: Charles Lieber
Airspace Management Branch
1500 Aviation Boulevard
Lawndale, CA 90261

Inyo County Free Library
PO Box 745
Lone Pine, CA 93545

Inyo County Free Library
PO Box K
168 N. Edwards St.
Independence, CA 93526

Inyo County Planning
PO Box L
168 N. Edwards St.
Independence, CA 93526

Kern County Library
California City Branch
9507 California City Boulevard
California City, CA 93505

Kern County Library
Tehachapi Branch
450 West F Street
Tehachapi, CA 93561

Los Angeles County Library
Lancaster Branch
601 W. Lancaster Boulevard
Lancaster, CA 93534

Kern County Library
Mojave Branch
16916-1/2 Highway 14
Mojave, CA 93501

Santa Ynez Band of Mission Indians
David Dominguez, Chairperson
P.O. Box 517
Santa Ynez, CA 93460

San Manuel Band of Mission Indians
Lynn R. LeRoy, Chairperson
P.O. Box 266
Patton, CA 92369

Tule River Reservation
Irma Hunter, Chairperson
P.O. Box 589
Porterville, CA 93258

Chemehuevi Reservation
Matthew Leivas Sr., Chairperson
P.O. Box 1976
Havasu Lake, CA 92363

Office of Historic Preservation
State Historic Preservation Officer
PO Box 942896
Sacramento CA 94296-0001

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Government Publications Department
Santa Barbara, CA 93106-9010

Santa Barbara Public Library
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Santa Barbara, CA 93101-2000

Vandenberg AFB Base Library
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Lompoc Public Library
601 East North Avenue
Lompoc, CA 93436-3406

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Santa Maria, CA 93454-5199

Michon L. Washington
Environmental Specialist
Federal Aviation Administration
800 Independence Ave, SW
Washington, DC 20591

Tara L. Wiskowski
30 CES/CEVPP
806 13th Street, Suite 116
Vandenberg AFB, CA 93437

APPENDIX C (Draft)
DISTRIBUTION LIST

AFFTC Technical Library
412 TW/TSDL
Edwards AFB, CA 93524

Antelope Valley Air Pollution Control District
43201 Division St., Ste. 206
Lancaster, CA 93639-4409
Attn: Charles L. Fryxell. APCO
(Or) Bret Banks, Operations Manager

Army Corps of Engineers
Los Angeles District
911 Wilshire Blvd.
PO Box 532711
Los Angeles CA 90053

Bureau of Land Management
Barstow Area Office
2601 Barstow Road
Barstow CA 92311-3221

Bureau of Land Management
Ridgecrest Area Office
300 S. Richmond Road
Ridgecrest, CA 93555-4436

California Department of Fish and Game
1416 Ninth Street
Sacramento, CA 95814

CALTRANS
Department of Transportation
District 9
500 South Main Street
Bishop, CA 93514

City of Lancaster
Planning Department
44933 N. Fern Ave.
Lancaster, CA 93534

City of Palmdale
Planning Department
38250 N. Sierra Highway
Palmdale, CA 93550-4798

Muhammad Bari
Director of Public Works
HQ NTC Ft. Irwin
Attn: AFZJ-PW-EV
PO Box 105097
Building 285
Fort Irwin, CA 92310-5097

Edwards AFB Base Library
95 SPTG/SVMG
5 West Yeager Blvd.
Building 2665
Edwards AFB, CA 93524-1295

Kern River Valley Library
7054 Lake Isabella Boulevard
Lake Isabella, CA 93240
Attn: Karen Leifeld, Branch Supervisor

Kern County Library
Wanda Kirk Branch (Rosamond)
3611 Rosamond Boulevard
Rosamond, CA 93560

Lahonton Regional Water Quality Control Board
15428 Civic Drive Suite 100
Victorville, CA 92392

Los Angeles County Library
Quartz Hill Branch
42018 N. 50th Street W.
Quartz Hill, CA 93536

Los Angeles County
Planning Department
Room 150 Hall of Records, 13th Floor
320 W. Temple Street
Los Angeles, CA 90012

Mojave Desert AQMD
14306 Park Ave.
Victorville, CA 92392-2310
Attn: Charles L. Fryxell, APCO

Native American Heritage Commission
915 Capital Mall, Room 364
Sacramento, CA 95814

John O'gara
Head of Environmental Planning
Environmental Office
Code 8G0000D
#1 Administration Circle
Naval Air Weapons Station
China Lake, CA 93555

Office of Planning and Research
California State Clearinghouse
PO Box 3044
Sacramento CA 95812-3044

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700 E. Palmdale Boulevard
Palmdale, CA 93550

San Bernardino County
Land Use Services Department
Planning Division
385 N. Arrowhead Ave., 1st Floor
San Bernardino, CA 92415-0182

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82805 Mountain View St.
Trona, CA 93562

US Department of the Interior
Fish and Wildlife Service
Ventura Field Office
2493 Portola Road, Suite B
Ventura, CA 93003-7726

US Department of the Interior
National Park Service
Death Valley National Park
PO Box 579
Death Valley, CA 92328

Environmental Protection Agency
Region IX
EIS Review Section
75 Hawthorne Street
San Francisco, CA 94105

Federal Aviation Administration
Western Pacific Region
Attn: Charles Lieber
Airspace Management Branch
1500 Aviation Boulevard
Lawndale, CA 90261

HQ AFMC/CEV
4225 Logistics Avenue, Suite 8
Wright Patterson AFB, OH 45433-5747

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PO Box 745
Lone Pine, CA 93545

Inyo County Free Library
PO Box K
168 N. Edwards St.
Independence, CA 93526

Inyo County Planning
PO Box L
168 N. Edwards St.
Independence, CA 93526

Kern County APCD
Attn: Thomas Paxson, P.E.
2700 M Street, Suite 302
Bakersfield, CA 93301-2370

Kern County Library
Beale Memorial Library, Main Branch
701 Truxton Ave.
Bakersfield, CA 93301

Kern County Library
Boron Branch
26967 20 Mule Team road
Boron, CA 93516

Kern County
Department of Planning and Development Services
2700 M Street, Suite 100
Bakersfield, CA 93301-2323

Kern County Library
California City Branch
9507 California City Boulevard
California City, CA 93505

Kern County Library
Tehachapi Branch
450 West F Street
Tehachapi, CA 93561

Los Angeles County Library
Lancaster Branch
601 W. Lancaster Boulevard
Lancaster, CA 93534

Kern County Library
Mojave Branch
16916-1/2 Highway 14
Mojave, CA 93501

US Senator Diane Feinstein
525 Market Street, Suite 3670
San Francisco CA 94105

US Senator Barbara Boxer
501 I Street, Suite 7-600
Sacramento CA 95814

Congressman McKeon
Antelope Valley Field Office
1008 W. Avenue M-14 #E-1
Palmdale, CA 93551

Santa Ynez Band of Mission Indians
David Dominguez, Chairperson
P.O. Box 517
Santa Ynez, CA 93460

San Manuel Band of Mission Indians
Lynn R. LeRoy, Chairperson
P.O. Box 266
Patton, CA 92369

Tule River Reservation
Irma Hunter, Chairperson
P.O. Box 589
Porterville, CA 93258

Chemehuevi Reservation
Matthew Leivas Sr., Chairperson
P.O. Box 1976
Havasu Lake, CA 92363

Office of Historic Preservation
State Historic Preservation Officer
PO Box 942896
Sacramento CA 94296-0001

Angeles National Forest
Supervisor's Office
701 N. Santa Anita Ave.
Arcadia, CA 91006

USDA Forest Service
Regional Office R-5
1323 Club Drive
Vallejo, CA 94592

USDA Forest Service
Pacific Southwest Region
Sequoia National Forest
900 West Grand Avenue
Porterville, CA 93257

California Department of Parks and Recreation
P.O. Box 942896
Sacramento, CA 94296

Sierra Club
Antelope Valley Group
P.O. Box 901875
Palmdale, CA 93590

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Response to Comments on the
Draft EA For the Orbital Reentry Corridor for Generic Unmanned LEV Landing – July 2002

<table>
<tr><th>Item</th><th>Page</th><th>Para./Fig./Table</th><th>Originator</th><th>Comment</th></tr>
<tr><td>1.</td><td>Page 3-10.</td><td></td><td>Debra Trindle FAA Air Traffic Division Airspace Specialist</td><td>Definition of Class A airspace is incorrect. Class A airspace does not include Alaska as stated in this definition. Class A airspace in Alaska has some exclusions that cause it to vary from the standard Class A airspace over the 48 contiguous states. The definition of Class A as written is incomplete as per 14 CFR part 71.33. However, since the definition contained in 14 CFR part 71.33 is lengthy, the existing definition could be modified to exclude Alaska. This would be a technically correct statement (but still not complete) without having to reproduce the entire definition from 14 CFR part 71.33.</td></tr>
<tr><th colspan="5">Response</th></tr>
<tr><td colspan="5">Changed definition of Class A airspace to read:
"Class A airspace is that airspace of the United States, including that airspace overlying the waters within 12 nautical miles of the coast of the 48 contiguous states, from 5,486 meters (18,000 feet) above MSL to and including FL600 (18,288 meters or 60,000 feet above msl) excluding the states of Alaska and Hawaii, Santa Barbara Island, Farallon Island, and the airspace south of latitude 25 degrees 04 minutes 00 seconds North."</td></tr>
<tr><td>2.</td><td>Page 3-10.</td><td></td><td>Debra Trindle</td><td>The first sentence of each of the three paragraphs describing Class B, C and D airspace respectively is not technically correct. The first sentence leads the reader to believe that the stated upper altitude limit is fixed and uniform throughout these categories of airspace. That is not correct. Suggest inserting the word “generally” before the word “ranges” in the first sentence of each of these three paragraphs.</td></tr>
<tr><th colspan="5">Response</th></tr>
<tr><td colspan="5">Changed the first sentence of each of the paragraphs to read:
"Class B airspace generally ranges from the surface to 10,000 feet….."
"Class C airspace generally ranges from the surface to 4,000 feet….."
"Class D airspace generally ranges from the surface to 2,500 feet…."</td></tr>
</table>

Response to Comments on the
Draft EA For the Orbital Reentry Corridor for Generic Unmanned LEV Landing – July 2002

<table>
<tr><th>Item</th><th>Page</th><th>Para./Fig./Table</th><th>Originator</th><th>Comment</th></tr>
<tr><td>3.</td><td>Page 3-10.</td><td></td><td>Debra Trindle</td><td>In the last paragraph describing Class E airspace, revise the last sentence to state “…Class E airspace ranges from 14,500 feet above msl up to but not including 18,000 feet msl…”</td></tr>
<tr><th colspan="5">Response</th></tr>
<tr><td colspan="5">Changed the last sentence in the last paragraph on page 3-10 to read:
"Unless designated at a lower altitude, Class E airspace ranges from 14,500 feet above msl up to but not including 18,000 feet above msl, including the airspace overlying the waters within 12 nautical miles of the coast of the 48 contiguous states and Alaska."</td></tr>
<tr><td>4.</td><td>Page 3-12.</td><td>Paragraph 3.2.1.1.</td><td>Debra Trindle</td><td>Paragraph 3.2.1.1. From the graphic depiction of Alternative A, it does appear to overly a portion of the Santa Barbara Class C airspace area, albeit a very small area. The next to last sentence in this paragraph may not be correct.</td></tr>
<tr><th colspan="5">Response</th></tr>
<tr><td colspan="5">Changed the first sentence in paragraph to read:
"Other than the special use airspace identified below (see Section 3.2.1.2), all airspace within Alternative A is Class A, Class C, Class D, or Class E controlled airspace, within which some or all aircraft may be subject to ATC."
Changed the next to last sentence in paragraph 3.2.1.1 to read:
"There is no Class B airspace within Alternative A."</td></tr>
<tr><td>5.</td><td>Page 3-12.</td><td>Paragraph 3.2.1.2 and Table 3-6.</td><td>Debra Trindle</td><td>Remove ATCAAs from paragraph 3.2.1.2 and Table 3-6. ATCAAs are not special use airspace and have no regulatory definition or operating criteria. To list them as such is misleading, since special use airspace has different operating rules and regulations than non-special use airspace.</td></tr>
<tr><th colspan="5">Response</th></tr>
<tr><td colspan="5">Removed the last paragraph on page 3-12. In Table 3-6 removed reference to Bakersfield ATCAA and Isabella ATCAA, and removed "Note: ATCAA - Air Traffic Control Assigned Airspace." Reference to ATCAAs will be removed from the document.</td></tr>
</table>

Response to Comments on the
Draft EA For the Orbital Reentry Corridor for Generic Unmanned LEV Landing – July 2002

<table>
<tr><th>Item</th><th>Page</th><th>Para./Fig./Table</th><th>Originator</th><th>Comment</th></tr>
<tr><td>6.</td><td>Page 3-15.</td><td>Paragraph 3.2.2.1</td><td>Debra Trindle</td><td>Paragraph 3.2.2.1 states that there is no Class B or C airspace in Alternative B. This is incorrect. At a minimum, the Sacramento International Class C and the Beale AFB Class C lie in this area according to the graphical depiction. Most likely there are more Class B and C areas, but I cannot determine that past the graphic depiction.</td></tr>
<tr><th colspan="5">Response</th></tr>
<tr><td colspan="5">Changed the first sentence in paragraph to read:

"Other than the special use airspace identified below (see Section 3.2.2.2), all airspace within Alternative B and within 750 nautical miles of Edwards AFB is Class A, Class C, Class D, or Class E controlled airspace, within which some or all aircraft may be subject to ATC."

Changed the next to last sentence in paragraph 3.2.2.1 to read:

"There is no Class B airspace within Alternative B."</td></tr>
<tr><td>7.</td><td>Page 3-16.</td><td></td><td>Debra Trindle</td><td>Same comment as number 5 above (including Table 3-7).</td></tr>
<tr><th colspan="5">Response</th></tr>
<tr><td colspan="5">Changed the first sentence in paragraph 3.2.2.2 to read:

"Within Alternative B…and the Isabella, Bakersfield, and Porterville MOAs (Figure 3-3 and 3-4)."
In Table 3-7, removed reference to Bakersfield ATCAA and Isabella ATCAA, and removed "Note: ATCAA - Air Traffic Control Assigned Airspace." Reference to ATCAAs will be removed from the document.</td></tr>
<tr><td>8.</td><td>Page 4-7.</td><td>Paragraph 4.2.1.1</td><td>Debra Trindle</td><td>Paragraph 4.2.1.1 discusses emergency contingency in the last section of this paragraph. It is highly unlikely that the NAS would be cleared of all traffic within plus or minus 5 minutes of the projected flight time of the unmanned LEV. Emergency situations are evaluated and handled by ATC on an individual basis, with the emergency aircraft being afforded priority handling over all other traffic. However, clearing airspace just because an emergency is in progress is not feasible or required.</td></tr>
</table>

Response to Comments on the
Draft EA For the Orbital Reentry Corridor for Generic Unmanned LEV Landing – July 2002

<table>
<tr><th>Item</th><th>Page</th><th>Para./Fig./Table</th><th>Originator</th><th>Comment</th></tr>
<tr><th colspan="5">Response</th></tr>
<tr><td colspan="5">Changed the next to last sentence in the 2nd paragraph on page 4-7 to read:

"Under emergency conditions there could be a temporary reduction in navigable airspace. Emergency situations are evaluated and handled by ATC on a case-by-case basis, whereby an emergency unmanned LEV or any aircraft experiencing an emergency would be afforded priority handling over all other traffic."</td></tr>
<tr><td>9.</td><td>Page 4-7.</td><td>Paragraphs 4.2.1.2 and 4.2.1.3</td><td>Debra Trindle</td><td>Paragraphs 4.2.1.2 and 4.2.1.3 both make reference to scheduling functions and/or scheduling coordination performed by TRACON. High Desert TRACON does not perform any scheduling of special use airspace, military training routes, etc. The TRACON may coordinate requests forwarded to them as per the last paragraph in 4.2.1.2, but on a time and workload-permitting basis. Scheduling tasks are performed for the R-2508 complex solely by the DoD, mainly the Central Coordinating Facility (CCF).</td></tr>
<tr><th colspan="5">Response</th></tr>
<tr><td colspan="5">Changed paragraphs 2, 3, and 4 of Section 4.2.1.2 to read:

"The LEV would enter the R-2508 and R-2515 restricted areas in the R-2508 Complex, however, these areas would not be adversely affected since accommodating unmanned LEV landings would be considered a matter of routine operations in that special use airspace. The agency using the restricted areas coordinates with the Central Coordinating Facility (CCF) who has the autonomous authority for the R-2508 Complex shared-use airspace. The CCF acts as the single point for coordination of activities with High Desert TRACON and other ATC/mission control facilities. In addition, the flight tests represent precisely the kind of activities that the Restricted Area special use airspace was created for in the early 1960s: namely, to accommodate national security and necessary military activities, and to confine or segregate activities considered to be hazardous to nonparticipating aircraft.

No new additional demands would be placed on existing special use airspace that could not be accommodated by airspace schedulers, and Alternative A would not require the assignment of new special use airspace, or require the modification of existing special use airspace. Consequently, there would be no adverse impacts to special use airspace.</td></tr>
</table>

Item	Page	Para./Fig./Table	Originator	Comment
(#9 Response Continued) The scheduling office for each special use airspace area (CCF within the R-2508 Complex) regulates the real-time activity schedule for any Restricted Area, MOA, or Warning Area that would be affected by an emergency landing. Special use airspace activities may be temporarily affected, but would be readily accommodated by airspace schedulers. In the event of an emergency landing within the reentry corridor, the U.S. Air Force would relay all required airspace requests to TRACON via the CCF for special use airspace. Emergency situations are evaluated and handled by ATC on a case-by-case basis, with an emergency unmanned LEV or any aircraft experiencing an emergency being afforded priority handling over all other air traffic." Changed paragraphs 1 and 2 of section 4.2.1.3 to read: "Establishment of an orbital reentry corridor would not affect military training routes below the Western Approach Reentry Corridor, Alternative A. Scheduling the use of R-2508 and the military training routes that transit that airspace is a normal function for the CCF. Therefore, no impacts would occur. Use of Restricted Areas R-2508 and R-2515 in the R-2508 Complex for unmanned LEV landings would not have an adverse impact on military training routes within the complex. Each military training route's "Origination Activity" or home base, which is responsible for communications and coordination with the military aircraft scheduled to use the affected routes, would be notified of the unmanned LEV landing schedule, and military training would be scheduled to ensure the appropriate separation between aircraft and the unmanned LEV. Thus, there would be short-term reductions in the availability of entire training routes, or individual segments. However, the rescheduling of military training route exercises is routine and would not constitute an adverse impact."				
10.	Page 4-8.	Paragraphs 4.2.1.3	Debra Trindle	Paragraphs 4.2.1.3 and 4.2.1.4. Same comment as number 8

Item	Page	Para./Fig./Table	Originator	Comment
		and 4.2.1.4.		above.
Response				
Changed paragraph 3 of section 4.2.1.3 to read: "In the event of an emergency landing within the reentry corridor, the U.S. Air Force would relay all required airspace requests for the affected routes to each military training route's "Origination Activity" or home base. During emergency conditions military aircraft would be re-scheduled, or routed around the airspace on a case-by-case basis, whereby an emergency unmanned LEV or any aircraft experiencing an emergency would be afforded priority handling over all other air traffic. Thus, there would be a temporary reduction in the availability of entire training routes, or individual segments." Changed paragraph 3 of section 4.2.1.4 to read: "In the event of an emergency landing within the entry corridor, the U.S. Air Force would relay landing requests to the FAA ATC Command Center for coordination with the Los Angeles ARTCC or the Oakland ARTCC. The ARTCC would provide traffic advisories to the extent possible to all aircraft operating in their affected airspace depending on higher priority duties of the controllers. Emergency situations are evaluated and handled by ATC on a case-by-case basis, with an emergency unmanned LEV or any aircraft experiencing an emergency being afforded priority handling over all other traffic. Under these emergency conditions there would be a temporary reduction in navigable airspace if air traffic is re-routed to avoid the emergency unmanned LEV. Should the emergency landing location be outside the continental United States, but in airspace under United States jurisdiction, oceanic ATC facilities would coordinate with ATC facilities of other governments as appropriate or feasible."				
11.	Page 4 -9.	Paragraph 4.2.1.5.	Debra Trindle	Paragraph 4.2.1.5. Same comment as number 8 above.
Response				

Response to Comments on the
Draft EA For the Orbital Reentry Corridor for Generic Unmanned LEV Landing – July 2002

<table>
<tr><th>Item</th><th>Page</th><th>Para./Fig./Table</th><th>Originator</th><th>Comment</th></tr>
<tr><td colspan="5">Changed paragraph 2 in section 4.2.1.5 to read:

"In the event of an emergency landing within the reentry corridor, the U.S. Air Force would relay all required airspace requests to the FAA ATC Command Center for coordination with the Los Angeles ARTCC or Oakland ARTCC. The ARTCC would provide traffic advisories to the extent possible to affected airports and airfields depending on higher priority duties of the controllers. Emergency situations affecting airports and airfields in the flight corridor would be evaluated and handled by ATC on a case-by-case basis, whereby an emergency unmanned LEV or any aircraft experiencing an emergency would be afforded priority handling over all other traffic. Under these emergency conditions there could be a temporary reduction in access to airports and airfields within the flight corridor when the unmanned LEV is maneuvered to an emergency landing site. Should the emergency landing location be outside the continental United States, but in airspace under United States jurisdiction, oceanic ATC facilities would coordinate with ATC facilities of other governments as appropriate or feasible."</td></tr>
<tr><td>12.</td><td>Page 4-10.</td><td>Paragraph 4.2.2.2.</td><td>Debra Trindle</td><td>Paragraph 4.2.2.2. Same comment as number 8 above.</td></tr>
<tr><th colspan="5">Response</th></tr>
<tr><td colspan="5">Changed paragraph 1 and 2 in section 4.2.2.2 to read:

"Similar to Alternative A, establishment of an orbital reentry corridor would have no adverse impacts on the existing special use airspace below the Northwestern Approach Reentry Corridor. The R-2508 and R-2515 Restricted Areas in the R-2508 Complex would not be adversely affected since accommodating an unmanned LEV or other manned or unmanned aerospace vehicles would be considered a matter of routine operations for that special use airspace. The agency using the restricted areas coordinates with the CCF who has the autonomous authority for the R-2508 Complex shared-use airspace. The CCF acts as the single point for coordination of activities with High Desert TRACON and other ATC/mission control facilities.

No additional demands would be placed on existing special use airspace that could not be accommodated by airspace schedulers, and utilization of the Northwestern Approach Reentry Corridor would not require the assignment of new special use airspace, or require the modification of existing special use airspace. Consequently, there would be no adverse impacts to special use airspace."</td></tr>
<tr><td>13.</td><td>Page 4-11.</td><td>Paragraph 4.2.2.2.</td><td>Debra Trindle</td><td>Last section of paragraph 4.2.2.2. Same comment as number 9 above.</td></tr>
</table>

Response to Comments on the
Draft EA For the Orbital Reentry Corridor for Generic Unmanned LEV Landing – July 2002

Item	Page	Para./Fig./Table	Originator	Comment
Response				
Changed paragraph 3 in section 4.2.2.2 to read: "In the event of an emergency landing within the reentry corridor, the U.S. Air Force would relay all required airspace requests to TRACON via the CCF for special use airspace. Emergency situations are evaluated and handled by ATC on a case-by-case basis, whereby an emergency unmanned LEV or any aircraft experiencing an emergency would be afforded priority handling over all other air traffic. The scheduling office for each special use airspace area regulates the real-time activity schedule for any Restricted Area, MOA, or Warning Area that would be affected by an emergency landing. Special use airspace activities may be temporarily be affected, but would be readily accommodated by airspace schedulers.				
14.	Page 4-11.	Paragraph 4.2.2.4	Debra Trindle	Paragraph 4.2.2.4 states that general aviation VFR traffic below R-2508 could be impacted by the LEV is not correct. The airspace in the Isabella MOA below R-2508 will not become restricted due to LEV operations. Just as today when the space shuttle is landing at EDW, general aviation VFR traffic will continue to transit this area below 18,000 feet.
Response				
Changed paragraph 2 in section 4.2.2.4 to read: "Under normal landing conditions (similar to the Space Shuttle Orbiter landing on Runway 22 at Edwards AFB), general aviation VFR traffic below the R-2508 Restricted Area (which extends from FL 200 to an unlimited altitude) would continue to transit the area below 18,000 feet msl. Although J-110 intersects the R-2508 Restricted Area northwest of Runway 22, the flight path of the unmanned LEV would cross that area above 100,000 feet above msl; thus no impacts are anticipated under normal approach conditions."				
15.	Page 4-12.	Paragraph 4.2.2.4.	Debra Trindle	Last section of paragraph 4.2.2.4. Same comment as number 8 above.

Response to Comments on the
Draft EA For the Orbital Reentry Corridor for Generic Unmanned LEV Landing – July 2002

<table>
<tr><th>Item</th><th>Page</th><th>Para./Fig./Table</th><th>Originator</th><th>Comment</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="5">Response</td></tr>
<tr><td colspan="5">Changed paragraph 3 of section 4.2.2.4 to read:

"In the event of an emergency landing within the reentry corridor, the U.S. Air Force would relay all required airspace requests to the FAA ATC Command Center via the CCF for coordination with the Los Angeles, Oakland, or Seattle ARTCC. The ARTCC would provide traffic advisories to the extent possible to all aircraft operating in their affected airspace depending on higher priority duties of the controllers. Emergency situations are evaluated and handled by ATC on a case-by-case basis, whereby an emergency unmanned LEV or any aircraft experiencing an emergency would be afforded priority handling over all other traffic. Under these emergency conditions there would be a temporary reduction in navigable airspace as air traffic is re-routed to avoid the emergency unmanned LEV. Should the emergency landing location be outside the continental United States, but in airspace under United States jurisdiction, oceanic ATC facilities would coordinate with ATC facilities of other governments as appropriate or feasible."</td></tr>
<tr><td>16.</td><td>Page 4-12</td><td>Paragraph 4.2.2.5.</td><td>Debra Trindle</td><td>Paragraph 4.2.2.5. Same comment as number 8 above.</td></tr>
<tr><td colspan="5">Response</td></tr>
<tr><td colspan="5">Changed paragraph 3 of section 4.2.2.5 to read:

"In the event of an emergency landing within the reentry corridor, the U.S. Air Force would relay all required airspace requests to the FAA ATC Command Center for coordination with the Los Angeles, Oakland, or Seattle ARTCC. The ARTCC would provide traffic advisories to the extent possible to affected airports and airfields depending on higher priority duties of the controllers. Emergency situations affecting airports and airfields in the flight corridor would be evaluated and handled by ATC on a case-by-case basis, whereby an emergency unmanned LEV or any aircraft experiencing an emergency would be afforded priority handling over all other traffic. Under these emergency conditions there could be a temporary reduction in access to airports and airfields within the flight corridor when the unmanned LEV is maneuvered to an emergency landing site. Should the emergency landing location be outside the continental United States, but in airspace under United States jurisdiction, oceanic ATC facilities would coordinate with ATC facilities of other governments as appropriate or feasible."</td></tr>
<tr><td>17.</td><td>General Comment</td><td></td><td>Debra Trindle</td><td>Overall the document gives the impression that in the event of an emergency, airspace will be sterilized and FAA ATC facilities</td></tr>
</table>

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Item	Page	Para./Fig./Table	Originator	Comment
				will perform a range of coordination functions for the DoD, including scheduling of special use airspace. These assumptions are outside the bounds of the scope of an environmental assessment and should not be in the document. Also, the FAA facilities referenced in the document have not agreed to any requests/requirements beyond normal ATC procedures, and are not obligated to such.
Response				
Text will be revised to indicate that FAA ATC facilities would provide traffic advisory services depending on the higher priority duties of the controllers.				
18.	Summary - Page 6		Charles Lieber FAA Air Traffic Division Environmental Specialist	Under both the Natural Resources and Noise discussions, the document makes reference to “61 decibels” as the ambient noise level. For the purpose of describing ambient noise levels, the recognized noise descriptor is (Leq) and would used be to express an ambient noise level such as “61 Leq.” We request that all references in the document to ambient noise levels be changed to Leq
Response				
The referenced sentence will be changed to "In addition, predicted sonic boom noise levels generated from an unmanned LEV are less than the ambient noise threshold C-Weighted Day-Night Level (CDNL) of 61 decibels (dBC)." Please note responses to Comment Nos. 21, 22, and 27 below and revised Section 3.10 Noise and Section 4.10 Noise.				
19.	Page 1-2	Figure 1-1	Charles Lieber	The map on this page should be titled: Figure 1-1 General Vicinity Map.
Response				
The Title for Figure 1-1 will be added. Figure 1-1 General Vicinity Map				
20.	Page 1-4		Charles Lieber	We request that last paragraph include the Federal Aviation Administration as a cooperating agency in the preparation of the document.

Response to Comments on the
Draft EA For the Orbital Reentry Corridor for Generic Unmanned LEV Landing – July 2002

<table>
<tr><th>Item</th><th>Page</th><th>Para./Fig./Table</th><th>Originator</th><th>Comment</th></tr>
<tr><th colspan="5">Response</th></tr>
<tr><td colspan="5">Replaced the last sentence in paragraph 1 of Section 1.0 of the Summary with the following sentence:

"The National Aeronautics and Space Administration (NASA) Dryden Flight Research Center (DFRC) and Federal Aviation Administration are cooperating agencies in the preparation of this EA."

In Section 2.0 of the Draft Finding of No Significant Impact, replaced the 2nd sentence with:

"The Proposed Action is being developed as a cooperative effort between the Air Force Flight Test Center Department of Defense, the National Aeronautics and Space Administration (NASA) Dryden Flight Research Center (DFRC), and Federal Aviation Administration to support the development and test of future unmanned entry vehicles for both NASA and the Air Force."

Replaced the last sentence in paragraph 2 of Section 1.1, page 1-4 with the following sentence:

"The National Aeronautics and Space Administration (NASA) Dryden Flight Research Center (DFRC) and Federal Aviation Administration are cooperating agencies in the preparation of this EA."</td></tr>
<tr><td>21.</td><td>Pages 3-70 through 3-76</td><td>Section 3.10 Noise</td><td>Charles Lieber</td><td>The discussion of noise refers to a day/night average sound level as Ldn. Although this descriptor is correct, it is not the commonly used acronym to express the day/night average sound level. Federal agencies have adopted the DNL as the descriptor to define a measurement of community noise exposure. The Community Noise Equivalent Level (CNEL) descriptor was additionally developed exclusively for the state of California. This descriptor is correctly indicated on Figure 3-16 of the document. We request that the document defines the difference between DNL and CNEL. Additionally, we request that the noise analysis correct all references of dBA to CNEL when referring to the noise contours.</td></tr>
<tr><th colspan="5">Response</th></tr>
</table>

<table>
<tr><th>Item</th><th>Page</th><th>Para./Fig./Table</th><th>Originator</th><th>Comment</th></tr>
<tr><td colspan="5">The commonly used acronym of DNL, rather than Ldn, will be used when describing the A-Weighted day/night average sound level. In addition, an expanded description of the different noise descriptors, including DNL and CNEL, and the differences between the descriptors were added (please also see the attached revised Section 3.10 Noise and 4.10 Noise of the EA). Finally, all references to the noise contours in Figure 3-16 will be correctly described as CNEL levels, rather than DNL levels.</td></tr>
<tr><td>22.</td><td>Page 3-74</td><td>Section 3.10.2 Project-Related Noise</td><td>Charles Lieber</td><td>This discussion on sonic boom analysis refers to C-weighted day-night sound levels (CDNL). The use of a C-weighted metric for analyzing lower frequency range impacts is common to overpressure studies but not common to industry noise standards. Therefore, we request that this section further defines why the document presents the C-weighted decibels matrix and how that matrix would compare to various sound levels on the A-weighted DNL scale. The document reviewer needs to have a clearer understanding of the two sound levels and why one is used for human annoyance and the other is used for impacts to building and structures.</td></tr>
<tr><td colspan="5">Response</td></tr>
<tr><td colspan="5">A description for how DNL levels compare to CDNL levels will be provided in Section 3.10 Noise (please also see the attached revised Section 3.10 Noise and 4.10 Noise of the EA).</td></tr>
<tr><td>23.</td><td>Page 4-27</td><td>Cumulative Impacts</td><td>Charles Lieber</td><td>The document clearly indicates in various sections that the EA is being prepared to study the potential impacts for just the “reentry and landing phase” of the intended test vehicle program. The document further states that the study of the “launch phase” will be the responsibility of the intended test vehicle program office. This dividing of the study documents clearly demonstrates to the public that segmentation of the project is occurring. NEPA allows for tiering (§1508.28) if the connected action is a national plan, program or policy statement and the project of study will be of lesser scope or site specific to the national plan. We strongly recommended that the document provides a discussion on the ‘other half of this project’, which is, the launch phase. This discussion should be presented in the cumulative impact section. Discussions should include how the vehicle is to be launched, from where it is to be launched, and at such time when the launch method and locations are “ripe” for discussion, the test vehicle</td></tr>
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<tr><th>Item</th><th>Page</th><th>Para./Fig./Table</th><th>Originator</th><th>Comment</th></tr>
<tr><td></td><td></td><td></td><td></td><td>program office will prepare the supporting environmental study. The launch phase is, by obvious reasons, a connected action to this study and must be disclosed.</td></tr>
<tr><td colspan="5" align="center">Response</td></tr>
<tr><td colspan="5">See response to Item # 26 below.</td></tr>
<tr><td>24.</td><td>Page 5-2</td><td>Section 5.2 Regulations</td><td>Charles Lieber</td><td>This section does not provide reference policies for the study of aircraft noise. We recommend a sub-section be added to reference applicable federal and Air Force regulations for the study of aircraft noise.</td></tr>
<tr><td colspan="5" align="center">Response</td></tr>
<tr><td colspan="5">We propose to add a discussion of the applicable federal and Air Force regulations for Aircraft Noise:
Aircraft Noise Regulations
Federal
Aviation Safety & Noise Abatement Act of 1979, 49 U.S.C. § 2101
Noise Control Act, 42 U.S.C. § 4901, et seq.
32 CFR Part 256, Air Installations Compatibility Use Zones (AICUZ)
OMB Circular 75-2, Compatible Land Uses at Federal Airfields, 26 March 1996
DoDI 4165.57, Air Installations Compatibility Use Zones (AICUZ), 8 November 1977
14 CFR Part 150, Airport Noise Compatibility Planning
California
California Code of Regulations, Title 21, section 5000 <i>et seq</i>.
Air Force
AFI 13-201, Air Force Airspace Management, 1 April 1998
AFI 32-7063, Air Installation Compatible Use Zone Program (AICUZ), 1 October 1998
Air Force Handbook (AFH) 32-7084, AICUZ Program Manager's Guide, 1 March 1999</td></tr>
<tr><td>25.</td><td>Page 5-10</td><td>Section 5.2.9 Safety and Noise</td><td>Charles Lieber</td><td>This sub-section references to occupational safety and does not address aircraft noise. Therefore, we recommend that the section be titled just Safety.</td></tr>
<tr><td colspan="5" align="center">Response</td></tr>
<tr><td colspan="5">Changed the title of Section 5.2.9 from "Safety and Noise" to "Safety".</td></tr>
<tr><td>26.</td><td>General</td><td></td><td>Charles Lieber</td><td>The launch phase of this program is a connected action to the</td></tr>
</table>

Item	Page	Para./Fig./Table	Originator	Comment
	Comment			proposed action. Disclosure of this connected action, and its potential environmental impacts, is critical in meeting the implementing provision of the National Environmental Policy Act. Unless the Environmental Assessment clearly explains the launch phase we contend that the document is not in compliance.

Response

We propose to add a paragraph and table identifying types of launch vehicles and launch sites that could be used to get the unmanned LEV into Low Earth Orbit. This section would also emphasize that the agency involved in the testing of the vehicle would be required to supplement the NEPA documentation with specific information on the environmental effects of the launch phase for their specific launch vehicle.

Inserted new paragraph into 4.15.1.1 Airspace and Land Use, entitled Space Launch Sites and Launch Vehicles:

"It will be the responsibility of the sponsoring agency and the manufacturer of the unmanned LEV to evaluate the environmental affects of the proposed launch phase of the program based on the specific launch sites and launch vehicle used to place the unmanned LEV into low earth orbit (LEO). As such, this EA does not evaluate the potential launch sites or launch vehicles, which would be an integral part of an unmanned LEV program.

Launch sites for this type of vehicle are typically referred to as spaceports. Fewer than two-dozen spaceports have been constructed since the world entered the Space Age. Some of these sites are well known and others are secret military sites. The busiest spaceports are Cape Canaveral, Florida, United States; Vandenberg AFB, California, United States; Baikonur, Russia; Plesetsk, Russia; Kourou, French Guiana; Tanegashima, Japan; Jiuquan, China; Xichang, China; and Sriharikota, India. Depending on the political realities and technical requirements, an unmanned LEV could be launched from one of these spaceports or one of the other military sites capable of launching payloads in excess of 13,636 kilograms (30,000 pounds). Figure 4-3 identifies the location of the primary international spaceports and Figure 4-4 identifies the location of current and proposed U.S. spaceports.

Since 1957, over 5,000 satellites and space vehicles have been boosted into orbit. As we move into the 21st century and beyond, this number is expected to increase by 70 to 80 launches per year as competing nations and commercial enterprises launch their payloads in support of their special interest. Most of these launches are projected to be in support of light to medium weight payloads (less than 5,400 kilograms). Currently there are less than 20 launch vehicles, as identified in Table 4-2, that are capable of placing the unmanned LEV into LEO.

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(Response #26 continued) Based on the projected recovery of unmanned LEVs for this program, the cumulative impact on projected launches is expected to be less than one percent each year from 2004 through 2008 and less than 5 percent for the remainder of the program."				
27.		General Comments	Tara L. Wiskowski GS-11 30CES/CEVPP	Sonic booms are described acoustically using metrics that take into account the short duration (up to ~1 second) of the noise. The noise and natural resources sections of this EA use acoustical metrics that average the sonic boom noise over a 24-hour period. This is an inappropriate acoustic measurement method and fails to address human annoyance factors caused by impulsive sounds. For example, a 1 psf sonic boom has an unweighted Peak overpressure of 127 dB. However, if this is averaged over a 1 hour period, the sound level is reduced to an unweighted L_{eq1h} of ~56 dB. Measuring the same noise using different metrics yields two vastly different noise levels. Twenty-four hour noise measurements are typically used for more continuous noise sources and not impulsive ones. Although impulsive noise annoyance can be estimated using 24-hour averages, it does not take into consideration two important aspects of annoyance, the physiological startle response and the annoyance due to the unexpected nature of the sonic boom. There is existing literature on the annoyance from sonic booms measured with the proper acoustical metrics. The EA states that the boom footprint was predicted using PCBoom, yet there is no map showing where the booms will impact, and whether special-status wildlife occur within the boom footprint area.

Item	Page	Para./Fig./Table	Originator	Comment
Response				
C-Weighted Sound Exposure Levels (CSELs) account for the short duration of the sonic boom and will also be used to evaluate impacts to humans and to wildlife in the EA. A comparison of the modeled sonic boom peak overpressure levels and CSELs will be added and compared with CDNL and DNL ambient noise thresholds. Please see the attached revised Section 3.10 Noise and 4.10 Noise of the EA. A discussion on sonic boom impacts to special-status wildlife was added to Section 4.9.1.2.				

Table 4-2 Projected Launch Vehicles

Launch Vehicle	Country	Payload Weight (kg) to LEO	Payload Weight (lbs) to LEO
Titan III/TOS	USA	14,515	31,933
Titan IV/Centaur	USA	18,144	39,917
Titan IV/SRM/Centaur	USA	18,144	39,917
Titan IV/SRM/IUS	USA	23,350	51,370
Delta IV Heavy	USA	22,727	50,000
Atlas V - 2 Solid	USA	17,273	38,000
STS (Space Shuttle)	USA	27,727	61,000
Ariane 5	Europe	18,000	39,600
Energia EUS	Russia	88,000	193,600
Energia EUS/RCS	Russia	88,000	193,600
H IIA LRB	Japan	14,000	30,800
Proton D-1-e	Russia	20,000	44,000
Proton D-1-e Star 27	Russia	20,000	44,000
Proton D-1-e Star 48B	Russia	20,000	44,000
Proton K	Russia	20,900	45,980
Proton M	Russia	22,500	49,500
Zenit 2	Russia	13,740	30,228

Note: LEO - Low Earth Orbit

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<table>
<tr><th>Item</th><th>Page</th><th>Para./Fig./Table</th><th>Originator</th><th>Comment</th></tr>
<tr><td>28.</td><td></td><td>General</td><td>Michon L. Washington, Environmental Specialist, FAA, Washington, D.C. Michon.Washington@FAA.gov, (202) 267-9305.</td><td>The area around Edwards Air Force Base was identified as being in non-attainment under the state and national standards for ozone and particulate matter with a diameter of 10 microns or less (PM_{10}). Was an air quality conformity analysis conducted for this proposed action?</td></tr>
<tr><td colspan="5">Response</td></tr>
<tr><td colspan="5">An air conformity applicability analysis was conducted for the proposed project which involved calculation of project-specific emissions and comparison with <i>de minimus</i> emission thresholds established by the U.S. EPA's conformity rule for general federal actions (Please see Section 4.1.1 for more details). Based on the conformity applicability criteria, the proposed project conforms to the most recent EPA-approved SIP and no further detailed conformity analysis is required.</td></tr>
<tr><td>29.</td><td></td><td>General</td><td>Michon L. Washington, Environmental Specialist, FAA, Washington, D.C. Michon.Washington@FAA.gov, (202) 267-9305.</td><td>Would the noise produced during reentry flights be monitored to ensure that noise generated by sonic booms would remain under the 61 decibel threshold that was estimated for residential areas?</td></tr>
<tr><td colspan="5">Response</td></tr>
<tr><td colspan="5">Edwards AFB does not anticipate monitoring noise levels during the reentry of the unmanned LEV. Records of noise complaints are routinely collected as part of the Community Relations Program.</td></tr>
<tr><td>30.</td><td></td><td>General</td><td>Michon L. Washington,</td><td>It should be noted that although the public may not have expressed concern with the noise generated by the reentry and</td></tr>
</table>

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<table>
<tr><th>Item</th><th>Page</th><th>Para./Fig./Table</th><th>Originator</th><th>Comment</th></tr>
<tr><td></td><td></td><td></td><td>Environmental Specialist, FAA, Washington, D.C. Michon.Washington@FAA.gov, (202) 267-9305.</td><td>landing of the Space Shuttle in the past, public perception and annoyance can be influenced by the source of the noise. Many people identify with the Space Shuttle and consider it to be a novelty or an attraction and may therefore be willing to accept noise generated from that source, but may not be willing to accept the same or lesser noise levels generated by military or commercial sources.</td></tr>
<tr><td colspan="5">Response</td></tr>
<tr><td colspan="5">Comment noted. Edwards AFB has a Community Relations Program that accepts sonic boom complaints related to the Space Shuttle and other vehicles. Other than the FAA and Vandenberg AFB, no other public comments have been received on the <i>Draft Environmental Assessment for the Orbital Reentry Corridor for Generic Unmanned Lifting Entry Vehicle Landing at Edwards air Force Base</i>.</td></tr>
<tr><td>31.</td><td></td><td>General</td><td>Michon L. Washington, Environmental Specialist, FAA, Washington, D.C. Michon.Washington@FAA.gov, (202) 267-9305.</td><td>Were Native American groups located at the Santa Ynez Band of Mission Indian Reservation, the San Manuel Band of Mission Indian Reservation, the Chemehueyi Reservation, and the Tule River Reservation contacted and consulted regarding the proposed action?</td></tr>
<tr><td colspan="5">Response</td></tr>
<tr><td colspan="5">The Santa Ynez Band of Mission Indian Reservation, San Manuel Band of Mission Indian Reservation, the Chemehueyi Reservation, Tule River Reservation, and Native American Heritage Commission, and State Historic Preservation Officer were all provided individual copies of the Draft EA for review and comment. Edwards AFB did not receive comments from any of these groups. Therefore it is deemed that further consultation with the Native American groups is not necessary.</td></tr>
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Public Notice

UNITED STATES AIRFORCE

Notice of Completion

Final Environmental Assessment (EA) and Finding of No Significant Impact (FONSI) for Orbital Reentry Corridor for Generic Lifting Vehicle Landing at Edwards Air Force Base, California

In compliance with the National Environmental Policy Act of 1969, and implementing regulations, the U.S. Air Force Flight Test Center (AFFTC) has prepared a Final EA and FONSI. The proposed action is to designate an orbital reentry corridor for the recovery of flights of unmanned Lifting Entry Vehicles (LEVs) from low earth orbit to final approach and landing at Edwards Air Force Base (AFB) in support of future Air Force and NASA research and development programs. The generic LEV reentry corridor is defined by the trajectory (ground track and altitude) of the vehicle as it reenters the earth's atmosphere from space.

With the recent reassignment of the United States Air Force Space and Missile Center to the Air Force Space Command, there is more focus on the military's need for reusable space vehicles. To support that need, the Air Force is developing road maps to define several approaches to develop the technology that will be applied to operational space vehicles. Current concepts for technology development involve testing unmanned vehicles and require the capability to support flight tests and operational flights of such vehicles in the continental United States. The EA serves as an assessment of acceptable reentry corridors as the foundation for environmental processes required to obtain the necessary approval for unmanned space transportation vehicle flights between 2004 and 2009.

The Final EA and FONSI are available at the Edwards Base Library; the AFFTC Technical Library; the Kern River Valley Library; various branches of the Kern County Library including Beale Memorial Main Branch, Boron Branch, California City Branch, Wanda Kirk Branch, Mojave Branch, and Tehachapi Branch; the Quartz Hill and Lancaster branches of the Los Angeles County Library; the Palmdale City Library; the Trona Library; the Inyo County Free Library; the University of California at Santa Barbara Library; the Santa Barbara Public Library; the Vandenberg Air Force Base Library; the Lompoc Public Library; and the Santa Maria Public Library. The Final EA and FONSI may also be viewed on the internet at www.ealev.com. The notification period is 30 days from the date of this publication. Further information on the Final EA and FONSI may be obtained from Mr. Gary Hatch at AFFTC/PA, 5 E. Popson Ave., Building 2650A, Edwards Air Force Base, California, 93524-1130. Mr. Hatch can also be contacted by phone at (661) 277-1454, by FAX at (661) 277-6145, or by email at gary.hatch@edwards.af.mil.